

ARB-TDA-REPORT No.48-78

REPORT ON AMBIENT AIR QUALITY SURVEY
IN THE VICINITY OF THE GREAT LAKES
PAPER COMPANY, LIMITED

THUNDER BAY

OCTOBER AND NOVEMBER, 1977

APRIL 1, 1978



Ontario

Ministry
of the
Environment

The Honourable
George R. McCague,
Minister

K.H. Sharpe,
Deputy Minister

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AIR RESOURCES BRANCH

Technology Development and Appraisal Section
Monitoring and Instrumentation Development Unit

ARB-TDA-Report No. 48-78

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Ontario Ministry of
the Environment,
880 Bay Street,
Toronto, Ontario.

April 1, 1978.

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01. SUMMARY

An ambient air monitoring programme was carried out in the city of Thunder Bay during October and November 1977. The main aim of this survey was to monitor selected pollutants in the vicinity of the Great Lakes Paper Company Limited plant of Thunder Bay.

The weather conditions that prevailed throughout most of this survey period were good for plume dispersion. Nighttime radiation cooling, with the resultant low level inversion, was essentially the only meteorological phenomenon that gave rise to any appreciable ground level concentrations of the selected pollutants.

Over 350 hours of data were accumulated and after analyses, the assessment of the ambient air quality at this locale was as follows.

The overall average for the entire survey, of the maximum 30-minute average concentrations for total reduced sulfur (T.R.S.) expressed as hydrogen sulfide was found to be 0.016 ppm with the associated standard deviation 0.026 ppm. For the sampling periods reported, the average concentration of hydrogen sulfide was 0.009 ppm with associated standard deviation of 0.015 ppm. The 30-minute average concentration of 0.020 ppm H_2S was exceeded only during five occasions. Entrapment by the ground-based radiation cooling phenomenon and the close proximity of the kraft mill to the monitoring sites accounted for these increased levels. Under these conditions, the maximum 30-minute average and instantaneous concentrations detected were 0.170 ppm and 0.622 ppm respectively.

Sulfur dioxide was also found to be present in the vicinity of the paper mill and the overall average of the 30-minute maximum average concentrations was found to be 0.027 ppm with associated standard deviation 0.060 ppm. For the survey periods reported, the average concentration of sulfur dioxide was 0.011 ppm with the associated standard deviation 0.028 ppm. The 30-minute average concentration of 0.30 ppm SO₂ was exceeded only once during this survey when the maximum 30-minute average and instantaneous values of 0.370 ppm and 3.2 ppm respectively, occurred during a digester blowdown. The schedule, for the blowdowns, as given by the mill officials, was consistent with the survey data and definitely evident throughout the analyses.

The average of the maximum 30-minute average concentrations was found to be below 0.10 ppm. Only during one survey period was this value exceeded and the 30-minute maximum average concentration was as high as 0.240 ppm. The maximum 30-minute average and instantaneous concentrations for all other monitoring periods were below 0.041 ppm and 0.050 ppm respectively.

On several occasions, as a direct result of the nocturnal inversion, the ambient air concentrations of oxides of nitrogen (NO_x) were in excess of 1.0 ppm. The suspected sources were urban home heating and Great Lake Paper Mill Company Limited boiler plant operations.

Sixty-three samples of Total Suspended Particulate Matter (T.S.P.) were collected by a network of five Hi-Volume samplers. The overall average concentration of TSP for the monitored area, based on a 24-hour sampling period, was found to be 98 ug/m³; However, thirteen of the sixty-three samples (it is

20%) exceeded the air quality criterion of 120 ug/m^3 . In particular, the thirty-six samples collected at the three monitoring sites in the vicinity of the urban area north east of the mill had an average value of 125 ug/m^3 . The maximum reported TSP loading was 410 ug/m^3 . This very high TSP loading was recorded in October 26-27, 1978 at the Dow Chemical plant (Site #1) under light westerly winds.

02. INTRODUCTION

As requested by the Northwestern Region, the Monitoring Instrumentation & Development Unit of the Air Resources Branch conducted an ambient air pollution survey in the city of Thunder Bay during October and November, 1977.

Hydrogen sulfide and sulfur dioxide were the suspected major pollutants originating from the kraft and sulfite pulp mills owned by the Great Lakes Paper Company, Limited, of Thunder Bay.

In addition to these and other gaseous pollutants, the Northwestern Region requested information regarding concentrations of airborne total suspended particulate matter (TSP) in the vicinity of this plant. A Hi-Volume sampler network was set up to perform this task.

03. SOURCE DESCRIPTION

The Great Lakes Paper Company Limited plant is located in the southwest sector of the city of Thunder Bay, Ontario. The plant area is situated near the junction of highways #11/17 and #61 and lies on the north bank of the Kaministiquia River, 10 km upstream from the Thunder Bay Harbour.

The plant includes a kraft pulp mill, a sulfite pulp mill, a waferboard mill, a stud mill and a significant boiler plant operation.

All monitoring sites were referenced to the main steam plant stack located in the boiler house area at the extreme southeast side of the mill complex. (Reference to Map #1 and UTM - military coordinates 32920-53573.)

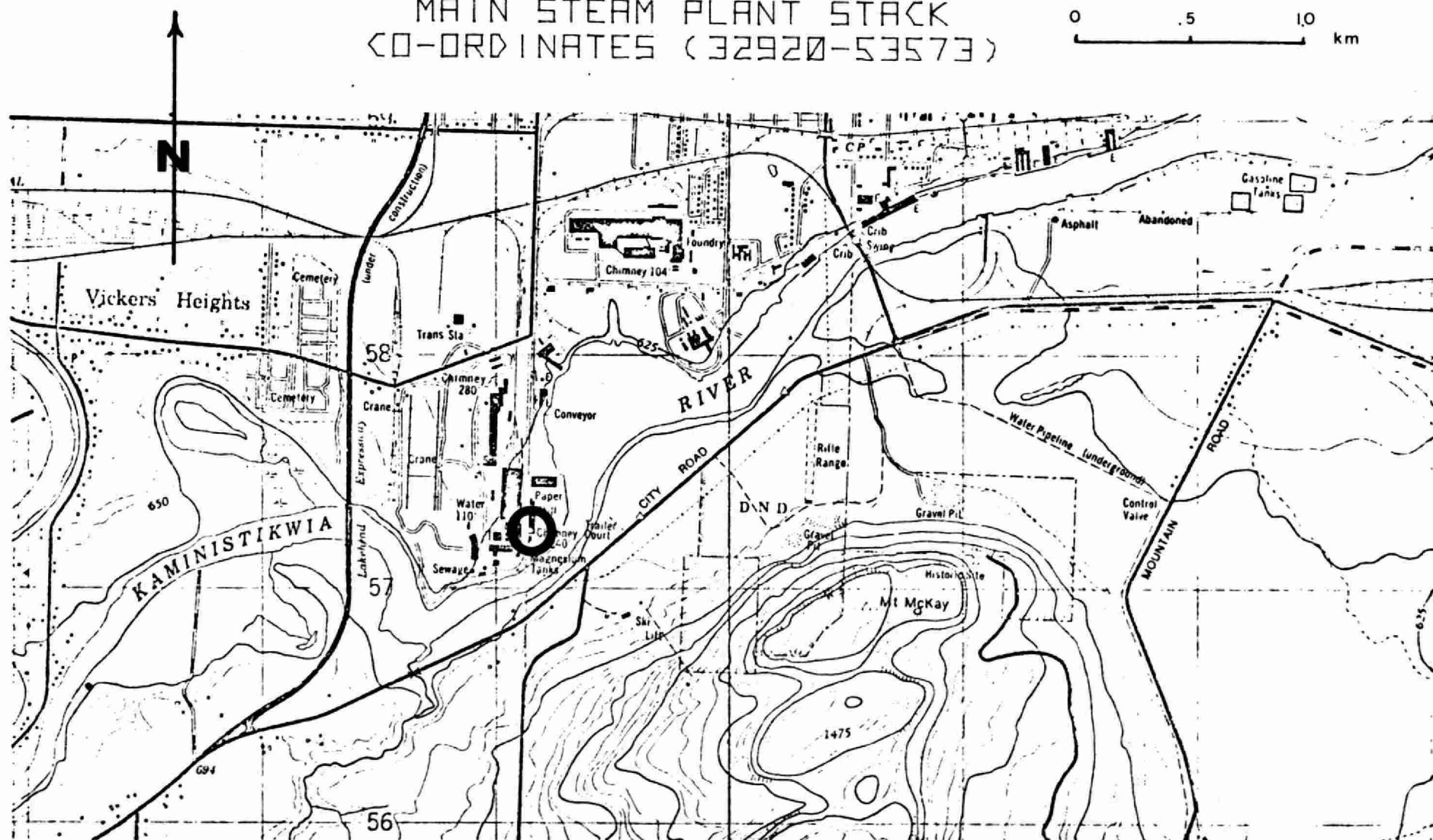
There exist two geological features that severely affect the wind dynamics in this area. These are the Kaministiquia River Valley and a large promontory (Mt. McKay) which is part of a group of hills (the Norwesters) oriented along a south west/northeast direction. These features cause "channelling" of the wind along the west/east direction.

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SOURCE

MAIN STEAM PLANT STACK
CO-ORDINATES (32920-53573)

0 .5 1.0
km



MAP #1

04. SURVEY TECHNIQUE

Two mobile air monitoring units, a 1971 Ford Econoline SP-200 van and a 1975 General Motors Corporation Transmode, were utilized to monitor the emissions from the Great Lakes Paper Company Limited plant. Both units were equipped with automated data acquisition systems (Ford - Hewlett & Packard 3480 system and the GMC - Hewlett & Packard 9830A mini-computer system) and on-board electric generators (Ford - 3.5 kW and GMC - twin 6kW). Automated, independent and continuous monitoring capabilities were a major feature of these units. The HP 9830A mini-computer system performed initial data analyses in the field (re: accuracy and validity) but the final data reduction and analyses was carried out by a larger system located within the Air Resources Branch at 880 Bay Street, Toronto.

Each unit had permanently installed analyzers for monitoring of sulfur dioxide, carbon monoxide, hydrogen sulfide, total hydrocarbons, methane, and oxides of nitrogen.

Following an assessment of wind-direction and wind-speed, the approximate location of maximum ground level concentration (glc) impingement zones was found and ambient air monitoring was initiated within these areas. Air quality was continuously monitored for at least one hour at each location, and whenever possible, further downwind monitoring was undertaken.

Five standard Hi-Volume samplers were used for monitoring of the mass of the Total Suspended Particulate Matter (T.S.P.). They were located at several distances and directions from the sources investigated. Glass-fibre filters were used as collection media and the collected samples of TSP were also analyzed for chlorides, sulfates, and total and elemental carbon.

05. MONITORING TECHNIQUE:

Sample Collection -

The ambient air samples were taken at a constant flow rate (approximately 0.4 cubic metres/min) by probes located on the vans from a point approximately 5 m above ground level. Air samples entered a manifold where each analyzer was parallel tapped with a minimal length of teflon sampling line. This arrangement ensured little or no sample degradation, minimal response time and minimal sample contamination due to ground level sources (e.g., entrained soil, vehicular traffic , etc.).

Instrumentation -

The instrumentation associated with each monitoring unit is presented in Tables #1 and #2 (pages 10 and 11).

As stated at the end of Section 04, five Hi-Volume samplers were utilized during the survey. All samplers were operated for 24-hour periods. TSP loadings were determined at the Ministry's Thunder Bay laboratory, with subsequent chemical analyses being conducted at the Ministry's central laboratory in Toronto.

Meteorological Analyses -

Meteorological conditions were monitored on a continuous basis by the instrumentation associated with the GMC Mobile Air Monitoring (MAM) unit (reference Table #2, page 1). No meteorological data were collected by the Ford MAM unit but since the survey status was a microscale phenomenon, and since both units were in close proximity, the GMC data were found to

be more than sufficient. Complementing this microscale monitoring, macroscale information regarding air mass movements and prognostics was obtained from the Thunder Bay Weather Office - (Environment Canada).

Calibration -

Analyzers and sources were calibrated before the survey. During the survey, the analyzers calibration was checked at least once every day using the sources and built-in electronic circuitry. All monitors were found to be extremely stable and the calibration remained within the prescribed limits throughout the duration of the survey. Immediately following completion of this survey, all instruments were rechecked in the laboratory and all calibration statistics were found to be satisfactory.

TABLE 1: INSTRUMENTATION - FORD

Instrument	Manufacturer	Analytical Technique	Maximum Sensitivity (full scale)
H ₂ S	Hartmann & Braun (H&B Prüfgasgenerator)	N/A	N/A
*H ₂ S Analyzer	H&B Picos	electrochemical	0.05 ppm
SO ₂	H&B Prüfgasgenerator	N/A	N/A
SO ₂ Analyzer	Wösthoff oHG Ultragas - 3	conductivity	1 ppm
O _c Analyzer Source	Dasibi 1003 - PC	Ultra-violet absorption	1 ppm
NO _x , NO ₂ , NO analyser	Bendix 8101-B	chemiluminescent	0.5 ppm
CO Analyzer	H&B Uras 2T	Infrared absorption (NDIR)	50 ppm
THC, CH ₄ , THC- CH ₄ Analyzer	Ingenieur - Produktions- Gruppe-München (IPM) RS-5	Dual Flame - ionization detector	50 ppm THC (as CH ₄)
CO/THC, THC-CH ₄ , CH ₄ Source	Matheson	Compressed gas	N/A

*See Table 2.

Instrument	Manufacturer	Analytical Technique	Maximum Sensitivity (Full Scale)
H ₂ S Source	Hartmann & Braun (H&B Prüffgasgenerator)	N/A	N/A
H ₂ S Analyzer	H&B Picos	electrochemical	0.05 ppm
SO ₂ Source	H&B Prüffgasgenerator	N/A	N/A
SO ₂ Analyzer	H&B Picoflux 2	conductometric	0.3 ppm
O ₃ Analyzer/Source	Bendix 8002	chemiluminescent	0.05 ppm
NO _x , NO ₂ , NO Analyzer	Bendix 8181-B	chemiluminescent	0.5 ppm
CO Analyzer	H&B Uras 2T	Infrared Absorption	50 ppm
THC, CH ₄ , THC-CH ₄ Analyzer	Ingenieur - Produktions-Gruppe München (IPM) RS-5	Dual flame ionization detector	50 ppm THC (as CH ₄)
Hg Analyzer	Scintrex HGP-2	Ultra-violet Absorption	200 ng/m ³
CO, THC, THC-CH ₄ , CH ₄ source	Matheson	compressed gas	N/A
Hydrocarbons chlorinated hydro- carbons, PAN, etc. Analyzer	Hewlett & Packard Gas Chromatograph 5830A System	Retention time as measured by ele- ctron capture, thermal conducti- vity, or flame ionization de- tectors	As set by calibration procedure.

<u>Instrument</u>	<u>Manufacturer</u>	<u>Scale</u>
**Wind Speed	Lambrecht gmbH	km/hr
**Wind Direction	Lambrecht gmbH	degrees
Temperature	Weather Measure (WM) T621	°C
Relative Humidity	WM-HM-111P	percentage
Barometric Pressure	WM-BM70-B242	millibars
Solar Radiation	WM Star Pyranometer	watts/cm ²

* Because the H₂S analyzer was also sensitive to the mercaptans and the HS⁻ group, the results of this analyzer were reported as Total Reduced Sulfur (TRS) and expressed as concentrations of hydrogen sulfide.

** These wind indicators are located on top of a 10 metre retractable mast.

06. SAMPLE SITE LOCATIONS:

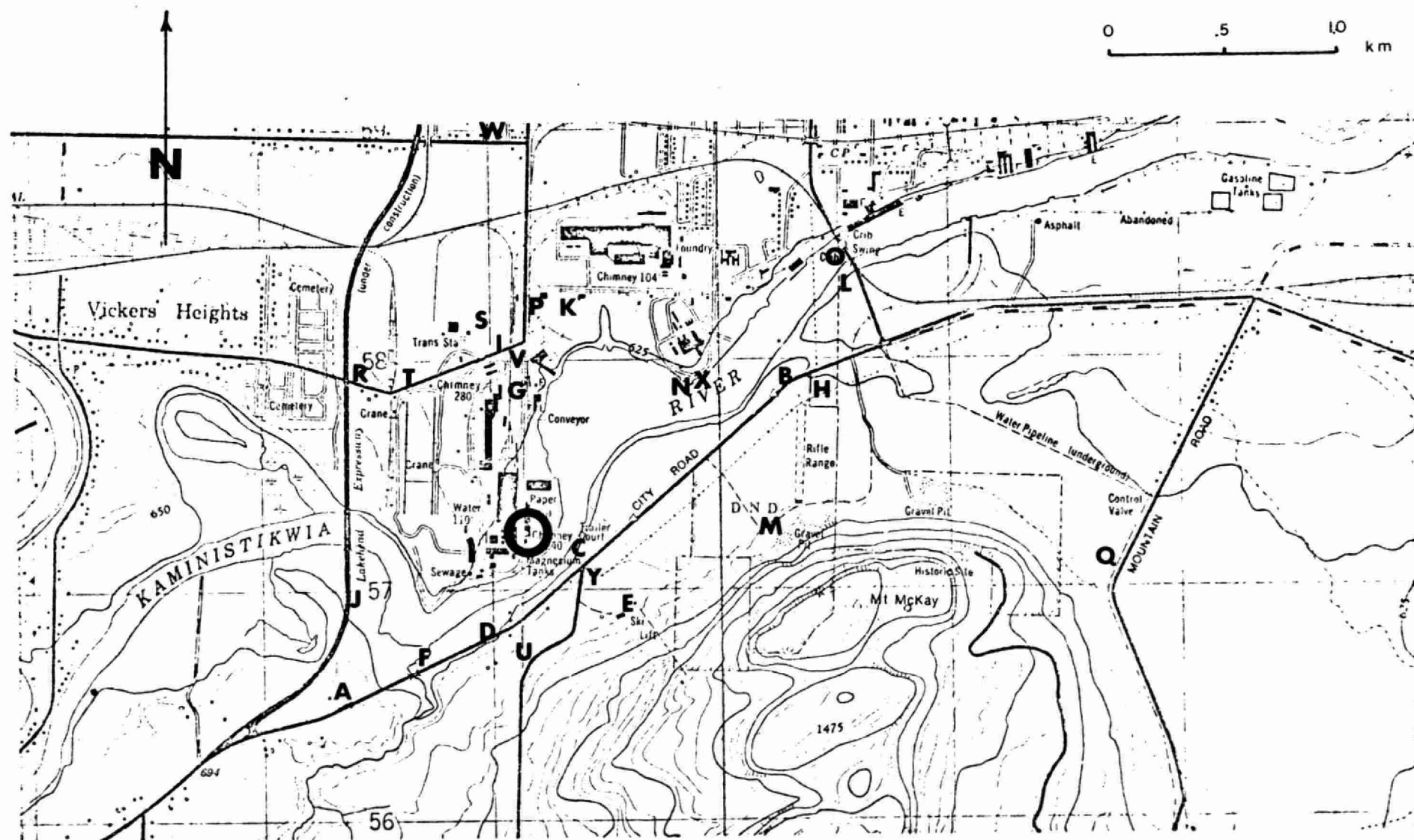
Ambient air monitoring sites are shown on Map #2 (page 13) and Table #3 (page 14) contains complete site descriptions for these locations.

Hi-Volume sampler monitoring sites are shown on Map #3 (page 17) and Table #4 (page 18) contains complete site descriptions for these stations.

All monitoring sites were referenced to the main steam plant stack located at the extreme southeast side of this mill (Reference to Map #1 and Section 03. pages 5 and 6).

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MONITORING SITES



MAP #2

TABLE 3.

MOBILE AIR MONITORING SITES

All monitoring sites were logged as

Thunder Bay II #X

<u>Site</u>	<u>Map Identification</u>	<u>Location, Description and UTM Coordinates</u>	<u>Distance & Bearing</u> (km) (degrees)		<u>Date</u>
1	A	Hwy #61B 32840 - 53566	1.1	220	Oct.20
2	B	Hwy #61B 33025 - 53578	1.2	045	Oct.21
3	C	Trailer Park 32930 - 53572	0.4	130	Oct.21
4	D	Hwy #61B 32900 - 53568	0.6	220	Oct.21
5	C	Trailer Park 32930 - 53572	0.4	130	Oct.21
6	E	Mt. McKay Ski Area 32950 - 58570	0.7	135	Oct.21
7	E	Mt. McKay Ski Area 32950 - 53570	0.7	135	Oct.21
8	C	Trailer Park 32930 - 53572	0.4	130	Oct.22
9	F	Mosquito Creek Bridge 32860 - 53567	0.9	220	Oct.22
10	E	Mt. McKay Ski Area 32950 - 53570	0.7	135	Oct.22
11	G	Main Gate of G.L.P. 32905 - 53579	0.5	005	Oct.23
12	H	Hwy# 61B; Rifle Range Rd. 33030 - 53578	1.1	060	Oct.23
15	I	100 m east of Main Gate GLP 32900-53580	0.4	330	Oct.24
16	J	Hwy#61 at Kaministikwia Road 32845-53568	0.9	220	Oct.24
17	K	Can. Car Property 32945 - 53583	1.0	020	Oct.24

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Table #3 (Cont'd)

<u>Sites</u>	<u>Map Identification</u>	<u>Location, Description and UTM Coordinates</u>	<u>Distance & Bearing (km) (degrees)</u>	<u>Date</u>
18	K	Can. Car Property, 32945 - 53583	1.0 020	Oct.25
19	L	C.N.R.A. Rec. Rink 33055 - 53583	1.7 055	Oct.25
20	E	Mt. McKay Ski Area 32955 - 53570	0.55 135	Oct.27
22	L	C.N.R.A. Rec. Rink 33055 - 53583	1.7 055	Oct.28
24	M	D.N.D. Rifle Range 33060 - 53574	1.5 090	Oct.29
27	L	C.N.R.A. Rec. Rink 33050 - 53583	1.7 055	Oct.31
28	N	Kaministikwia River Pt. 32980 - 53578	1.1 045	Nov.1
29	O	Kaministikwia River Bridge 33050 - 53584	1.8 050	Nov.1
30	K	Can. Car Ltd. Lot 32940 - 53583	0.9 020	Nov.1
31	K	Can. Car Ltd. Lot 32945 - 53583	0.85 015	Nov.2
33	P	Neebing & Montreal Sts. 32905 - 53583	0.9 000	Nov.2
34	P	Neebing & Montreal Sts. 32905 - 53583	0.9 000	Nov.2
35	L	C.N.R.A. Rec. Rink 33050 - 53583	1.7 055	Nov.3
36	L	C.N.R.A. Rec. Rink 33050 - 53583	1.7 055	Nov.3
37	L	C.N.R.A. Rec. Rink 33050 - 53583	1.7 055	Nov.3
38	Q	Indian Reserve Lookout Road 33170 - 53571	2.6 110	Nov.4

- 16 -
Table #3 (Cont'd)

<u>Site#</u>	<u>Map Identification</u>	<u>Location, Description and UTM Coordinates</u>	<u>Distance & Bearing (km) (degrees)</u>	<u>Date</u>
39	R	Broadway Ave. & Hwy #61 32835 - 53579	0.9 315	Nov.5
43	S	G.L.P. Woodlot 32875 - 53583	0.8 350	Nov.5
44	R	Broadway Ave. & Hwy #61 32835 - 53580	1.0 315	Nov.6
45	T	1/2 mile E. of Broad- way & Hwy #61 32840 - 53577	0.8 290	Nov.6
46	R	Broadway Ave. & Hwy #61 32835 - 5358	1.0 315	Nov.6
47	U	Mt. McKay Road 32920 - 53567	0.7 180	Oct.23
48	C	Trailer Park 32930 - 53572	0.4 130	Oct.26
49	V	Broadway & Neebing Ave. 32900 - 53581	0.8 350	Nov.2
50	V	Broadway & Neebing Ave. 32900 - 53581	0.8 350	Nov.2
51	W	Roselawn & Metcalfe Sts. 32910 - 53590	1.6 350	Nov.2
53	X	Hacquoil Construction Company 32985 - 53579	1.2 045	Nov.3
54	Y	Hwy#61B & Mt. McKay Rd. 32940 - 53572	0.3 135	Oct.22

NOTE: In this table, the Transmode MAM unit's locations were presented first (Sites#1 through#46 inclusively). They were presented in chronological order, however, some omissions were made. These omissions were based on invalid/insufficient data or data that was logged solely for calibration statistics.

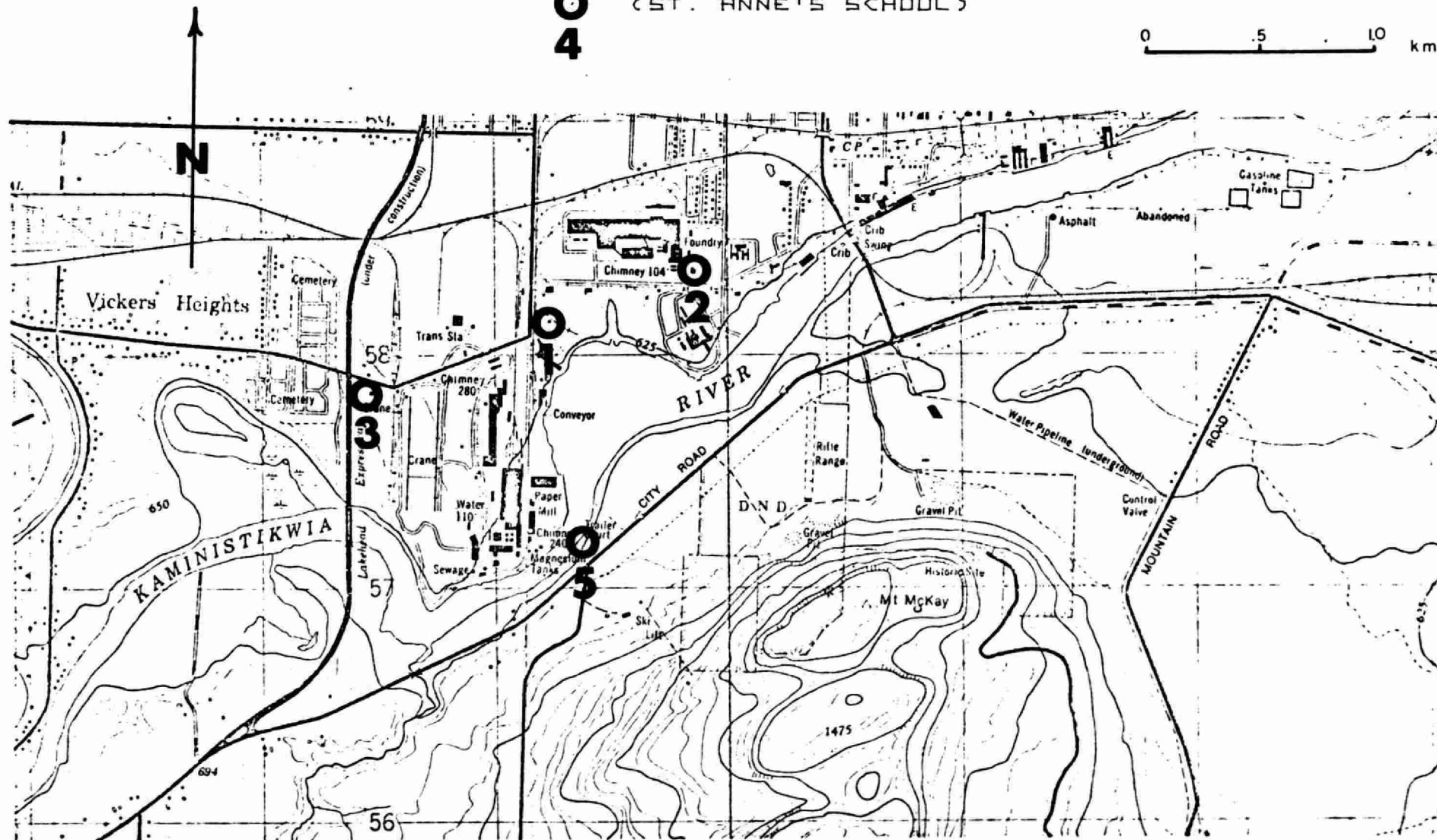
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HI-VOL SITES

0
4

(ST. ANNE'S SCHOOL)

0 .5 1.0 km



MAP #3

TABLE # 4

HIGH VOLUME SAMPLERS - SITE DESCRIPTION

<u>Site #</u>	<u>Location & Description</u>	<u>Distance & Direction from Source</u>
#1	Dow Chemical Storage Area (32935 - 53583)	0.8 km & 5 degrees
#2	Can-Car, Roof Office Bldg., (32980 - 53584)	1.2 km and 30 degrees
#3	Highway #61 & Broadway (Mr. M. Tocheri Pro- perty) (32840 - 53579)	0.9 km and 305 degrees
#4	St. Anne's School (32950 - 53594)	2.2 km and 10 degrees
#5	Trailer Court on Highway #61B (32950 - 53573)	0.3 km and 120 degrees

07. RESULTS:

Definition of Terms -

Scanning Time: Frequency of interrogation of the monitoring instrumentation by the Data Acquisition Systems.

Time: Time of first and final scans used to determine running averages.

Number of Readings: Number of scans.

All statistical values are based on instantaneous recorded values and all results are expressed in parts per million (ppm). An example of the processed data format incorporated in this survey report is presented in Table #5 (page 21). Due to the voluminous nature of these data, a special addendum to this report entitled; "Ambient Air Quality Survey, The Great Lakes Paper Company Limited, Thunder Bay , October and November 1977; Compilation of Time Averaged Data", will accompany this report and will be presented upon request.

Although hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) were the gaseous pollutants of the primary interest, ozone (O_3) and the oxides of nitrogen (NO_x , NO_2 , NO) were also monitored throughout this survey. These results are presented in Tables #6 and #7 (pages 31 to 36 inclusive). Supplementing these tables of statistical results, concentration versus time graphs for H_2S , SO_2 , NO_x and O_3 are presented in Figure #1 to 15 (pages 43 to 57 inclusive).

In order to identify hydrogen sulfide and sulfur dioxide source locations, wind-rose/concentration analyses were also performed (reference to Maps #4 to #12 (pages 58 to 66 inclusive)).

In addition to these gaseous pollutants, total suspended particulate matter (TSP) data were also accumulated. The analyzed data are presented in Table #8 (pages 37 to 41 inclusive).

TABLE #5.

Processed Data Format

Thunder Bay II #5

(Further Analyses are Presented as an
Addendum to this Report)

DATE: OCT 21 1977
SCAN TIME: 30 SEC
AVERAGING TIME: 30 MIN
LOCATION: HWY #618 IN TRAILER PARK;(32930-53572);0.4KM; 130 DEG/SOURCE

TIME	CO NO2 TEMP WIND DIRECTION	H2S NO HUMIDITY	SO2 OZONE BAROMETER	NOX SOLAR RAD WIND SPEED
14:40----15:10	2.4E+00 1.8E-02 16 338	1.0E-02 3.3E-02 24	7.5E-03 2.9E-02 994	4.8E-02 5.1E-02 10
14:55----15:25	2.2E+00 1.9E-02 16 308	1.4E-02 4.0E-02 23	1.3E-02 3.1E-02 994	5.4E-02 4.8E-02 10
15:10----15:40	1.1E+00 1.9E-02 16 293	1.6E-02 3.3E-02 24	3.0E-02 3.5E-02 993	5.0E-02 4.6E-02 11
15:25----15:55	1.3E+00 2.1E-02 16 303	1.7E-02 3.5E-02 24	4.3E-02 3.5E-02 993	5.4E-02 4.6E-02 10
15:40----16:10	1.1E+00 1.9E-02 15 314	1.7E-02 4.0E-02 24	2.6E-02 3.7E-02 993	5.6E-02 4.3E-02 13

STATISTICS

*NUMBER OF READINGS 206

POLLUTANT	MINIMUM VALUE	MAXIMUM VALUE	ARITHMETIC MEAN	STANDARD DEVIATION	GEOMETRIC MEAN	GEOMETRIC STD. DEV.
CO	1.00E-06	2.06E+01	1.40E+00	2.48E+00	5.70E-01	1.02E+01
H2S	4.89E-03	2.90E-02	1.46E-02	4.13E-03	1.40E-02	1.35E+00
SO2	4.86E-03	3.62E-01	1.93E-02	3.56E-02	1.12E-02	2.35E+00
NOX	1.95E-02	1.32E-01	5.14E-02	1.57E-02	4.92E-02	1.35E+00
NO2	1.00E-06	5.33E-02	1.37E-02	7.20E-03	1.68E-02	2.16E+00
NO	8.25E-03	1.11E-01	3.54E-02	1.56E-02	3.22E-02	1.59E+00
OZONE	1.87E-02	4.61E-02	3.40E-02	5.64E-03	3.35E-02	1.20E+00
SOLAR RAD	2.26E-02	5.36E-02	4.59E-02	5.10E-03	4.56E-02	1.13E+00
TEMP	14	17	15	1		
HUMIDITY	0	30	24	5	15	18
BAROMETER	993	994	994	0	994	1
WIND SPEED	0	40	15	7	13	2

08. DISCUSSION:

During the survey period, meteorological conditions were unfavourable for ground-level ambient air monitoring. The air mass frontal analyses and vertical structures showed that all air mass inversion layers were located well above stack height and that essentially stagnant atmospheric conditions were present throughout the survey. The plume was often observed to be aloft and intact and the effective stack heights were at least twice their physical heights. The average wind speed throughout the duration of this survey was approximately 7 km/hr and the maximum reported wind speed was approximately 25 km/hr. Predominantly southerly winds prevailed.

The only meteorological phenomenon that gave rise to appreciable ground level concentrations of pollutants during this survey was night-time radiation cooling. As a direct result of this cooling, a low-level nocturnal inversion layer was set up and did cause trapping of emissions. Calm winds, cool nights and early morning fogs were characteristic of this phenomenon. The subsequent "burn-off" of the early morning fog helped disperse low level emissions and again yielded low ground-level concentrations. Reported surveys Thunder Bay II #17, #37 and #38 were very good examples of this phenomenon.

Over 350 hours of data were accumulated and statistically evaluated. It is felt that the results presented in this report are a realistic summary of the data collected during the survey in the vicinity of the Great Lakes Paper Company Limited plant.

Under calm conditions when definite source identification was impossible, the Ontario Air Quality criteria were used in assessing allowable limits for atmospheric pollutants (for example 1-hour averages for NO_x and 24-hour averages for TSP). When definite source identification was possible, the 30-minute average concentration standards as set down by the Ontario Environmental Protection Act (Schedule 1, June 1977) were used.

TOTAL REDUCED SULPHUR - expressed as Hydrogen Sulfide

The H_2S analysers used in mobile air monitoring units were also sensitive to the mercaptans and the HS group. The recorded data may be expressed as total reduced sulfur (TRS), however since hydrogen sulfide was the predominant component, all results in this report are expressed as concentrations of hydrogen sulfide. Monitoring of hydrogen sulfide was carried out at every site during this survey. With a few exceptions, essentially all the acquired data demonstrated that the observed concentrations were at, or below the 30-minute average of 0.020 ppm. The overall average, for the entire survey, of the maximum 30-minute average concentration observed at each site was 0.016 ppm with associated standard deviation of 0.026 ppm. For all the survey periods reported, the average concentration of hydrogen sulfide was 0.009 ppm with associated standard deviation of 0.015 ppm. (Reference to Table #7, pages 34 to 36).

The only exceptions when the 30-minute average concentrations of H_2S exceeded 0.02 ppm, were at Sites #2, 11, 15, 47 and 50.

The maximum 30-minute average concentration was 0.170 ppm at Site #50 on November 2, 1978. This concentration was recorded at the railway crossing near the corner of Broadway and Neebing Avenues and it was believed that it originated from the low level emissions from the lime kiln and liquor recovery areas.

On this and the other four occasions, the elevated hydrogen sulphide levels may have been directly attributable to these emissions combined with the nocturnal inversion phenomenon and the geographical entrainment features of the area surrounding this plant. (Section 03, Source Description, page 5.)

Wind roses for Sites #2, #37 and #46 clearly point to the kraft and sulfite pulp mills owned by the Great Lakes Paper Company Limited as the major sources of this pollutant.

SULPHUR DIOXIDE

Monitoring of this pollutant was carried out at every site during this survey. The analyzed data are presented in Table #6, page 31-33, and may be discussed under the following three conditions:

- i) Wind speed less than 10 km/hr;

Under these meteorological conditions, plume dispersion was excellent and essentially no high ground impingement zones were found. Approximately 75% of the reported 42 monitoring periods may be classified as members of this group. The average of the maximum 30-minute average concentrations for SO_2 during these periods was 0.019 ppm with associated standard deviation 0.026 ppm.

Again, the presence of a nocturnal inversion with its subsequent morning "burn-off" was noted. Surveys #7 and #39 were good examples of this phenomenon and the maximum 30-minute average concentration during these surveys was found to be approximately 0.070 ppm.

Upon examining the wind-rose analyses for these monitoring periods, an apparent discrepancy regarding source location was found. There appeared to be two sources for this gaseous pollutant - i.e., the Hawker Siddeley Canada Limited plant (Can-Car) and the Great Lakes Paper Company Limited plant (refer to wind-roses for Sites #17, #31, and #46.) However, wind rose analyses at wind velocities less than 5 km/hr should be considered only

as indicative because of the greater uncertainty in the wind direction determinations at these low wind speeds.

ii) Wind speed greater than 10 km/hr;

During unidirectional winds the MAM units were located directly downwind of the plant (refer to concentration curves and wind-roses for Sites #6, #7, #18, #19, #37, and #38). Very low concentrations of SO_2 were detected (approximately 0.020 ppm for the overall average of the 30-minute maximum averages) however, the pulp mill complex owned by the Great Lakes Paper Company Limited was very well defined as the source. The "channelling" effect of the Kaministiquia River Valley and the Norwesters was also occurring during these monitoring periods.

iii) Sulfite mill-digester blowdowns:

One of the main aims of this study was to monitor the atmosphere during the digestors blowdowns. This process was considered the main source of sulfur dioxide. The digester stack area was located at the extreme south side of the plant. The blow-down schedule was obtained from the Great Lakes Paper Company, Limited and it was found that times of peak SO_2 concentrations definitely conformed to this schedule (refer to concentration analyses for Sites #7, #19, and #37). This coincidence of peak sulfur dioxide concentrations and blowdowns was even detected at ppb levels (Sites #27, #46, and #53). It was brought to our attention by mill officials that throughout the weekdays, one or more digesters may be malfunctioning due to the ongoing repair/maintenance programme implemented by this mill. Hence may have accounted for increased sulphur dioxide concentrations during these periods.

iv) Summary of Sulfur Dioxide

For all reported monitoring periods, the overall average of the 30-minute maximum average concentrations was 0.027 ppm with associated standard deviation 0.060 ppm. The average of all recorded sulfur dioxide concentrations was 0.011 ppm with associated standard deviation 0.028 ppm.

OZONE:

Ozone was detected in low concentrations during this survey and a summary of the analyzed data is presented in Table 7; pages, 34 to 36. Except for location TBII #15, the 30-minute maximum average concentrations were below 0.1 ppm. The overall average of the 30-minute maximum average concentrations was 0.033 ppm with associated standard deviation 0.037 ppm. For the monitoring periods reported, the maximum 30-minute average concentration of O_3 at one site was 0.240 ppm. This value was recorded during the morning hours of October 24, 1977 (approximately 11:00 a.m.) under calm weather conditions.

OXIDES OF NITROGEN

The oxides of nitrogen were also monitored during this survey and a summary of the analyzed data is presented in Table #8, page, 37 to 41.

On several occasions, 30-minute average and 1-hour average concentrations of NO_x greater than 0.500 ppm were detected. These monitoring periods were night time observations and the maximum concentrations often occurred between 0400 and 0800 hours (refer to observations on October 21, 22, 23, 23, 29 and November 2, 1977). Each one of these nights was initially clear and calm and the subsequent mornings were cool (temperatures near freezing) with radiation fog present.

Since the winds were calm during these periods of high NO_x readings, definite source identification was impossible (refer to wind-rose for TBII # 17 on page 48 and discussion on page 22 regarding wind vane.) A multiplicity of sources (i.e., the Great Lakes Paper Company Limited, Hawker Siddeley Canada Limited (Can-Car) and home heating) was inferred for this pollutant. Since vanadium is indicative of liquid fossil fuel combustion selected Hi-Volume filters for October 23 and 24 were analyzed for this element (refer to Table 8, pages 37 and 40). Sulfur and sulfate analyses were also carried out in order to identify the major type of fossil fuel consumed in this area. Since only trace amounts of vanadium and sulfur compounds were detected, definite source identification was impossible.

Daytime "burn-off" of the radiation fog dissipated the oxides of nitrogen and an increase in ozone was detected during these periods. This phenomenon is clearly depicted by the results of TBII #'s 10 to 13 inclusive.

In summary, the overall average concentration for oxides of nitrogen during the reported survey periods was 0.164 ppm with associated standard deviation 0.205 ppm. Occasionally, the 30-minute average and the instantaneous concentrations of NO_x exceeded 1.000 ppm (refer to addendum to this report and Table #8, page 37).

HI-VOLUME ANALYSES:

Five Hi-Volume samplers were utilized to determine integrated TSP mass loadings. This five-unit network was placed around the plant area with three of the five samplers located in the zone of population concentration to the northeast (Map #3 and Table #4).

Between October 22 and November 6th, sixty-three samples were collected and were analyzed for total suspended particulate matter (TSP), sulfates ($\text{SO}_4^{=}$), chlorides (Cl^-), free carbon (mainly coal, coke and graphite) and total carbon (free carbon plus carbonates and organic compounds). A summary of these results is presented in Table #8, pages 37 to 41 inclusive.

i) Total Suspended Particulate (TSP):

Of the 63 samples, 13 were found to have TSP loadings in excess of the air quality criterion of 120 ug/m^3 based on a 24-hour sampling period. The majority of these high TSP loadings were recorded during the period between October 25th and 29th. During this time the winds were light (approximately 10 km/hr) and from the southwest. Analyses of Sites #1, #2 and #4 show that the Great Lakes Paper Company, Limited plant was the only possible source. The maximum concentration of TSP occurred during October 26-28, at the Dow Chemical Site (#1) and it was found to be 410 ug/m^3 .

The minimum concentration of TSP was recorded on November 2-3 at the M. Tocheri Site (#3). This concentration value, based on a 24-hr sampling period, was 10 ug/m^3 and the winds were light and southerly.

ii) Sulfates:

Hi-Volume samples were analyzed for sulfate ($\text{SO}_4^{=}$) content and the overall average concentration was found to be 7 ug/m^3 . Therefore 8% of the total suspended particulate matter, was composed of sulfates. Based on a 24-hour sampling time, the maximum concentration of sulfates was found to be 18 ug/m^3 at the Can-Car site (#2) on October 24-25th.

iii) Chlorides

Chlorides (Cl^-) analyzed from the 63 samples were found to be approximately 1% of the total suspended particulate matter. The overall average concentration level for this pollutant was 1 ug/m^3 . Based on a 24-hour sampling time, the maximum concentration was found to be 5 ug/m^3 and this sample was acquired on October 25-26 at the Can-Car Site (#2).

iv) Carbon

A considerable percentage (approximately 17%) of the total suspended particulate matter was carbon. The total carbon overall average concentration, based on 24-hour sampling period was found to be 17 ug/m^3 . Again the maximum concentration for total carbon was found to be 56 ug/m^3 at the Can-Car Site (32) on October 28-29.

Twenty-two percent of the total carbon was found to be free carbon (i.e., coal, coke and graphite). Thus it was found that approximately 4% of the total suspended particulate matter was composed of free (elemental) carbon.

Based on a 24-hour sampling time, the maximum average concentration of free carbon was 10 ug/m^3 on October 28-29 at the Can-Car site (#2).

TABLE # 6A

Contaminant Levels in Thunder Bay

UNITS PPM

Site LOCATION	Date Oct. '77	Monitored Period	Instantaneous Concentration				30-min Maximum Average Concentration		Sample Period Mean Concentration		Scan Time (min.)
			SO ₂		H ₂ S		SO ₂	H ₂ S	SO ₂	H ₂ S	
			Min.	Max.	Min.	Max.					
TBII #1	20	17:58-07:58	0.001	0.020	0.001	0.005	0.004	0.001	0.001	0.001	1.0
TBII #2	21	10:13-12:13	0.001	0.065	0.007	0.034	0.021	0.021	0.006	0.014	1.0
TBII #3	21	12:30-13:00	0.001	0.001	0.010	0.018	0.001	0.012	0.001	0.012	1.0
TBII #4	21	13:21-14:21	0.008	3.200	0.001	0.016	0.370	0.010	0.185	0.009	1.0
TBII #5	21	14:40-16:10	0.005	0.362	0.005	0.029	0.043	0.017	0.019	0.015	0.5
TBII #6	21	16:41-19:26	0.004	0.063	0.001	0.024	0.030	0.016	0.020	0.014	0.5
TBII #7	21	19:59-09:20	0.002	0.186	0.003	0.024	0.071	0.015	0.012	0.011	1.0
TBII #8	22	12:06-14:06	0.001	0.065	0.001	0.006	0.009	0.004	0.004	0.002	1.0
TBII #9	22	14:31-17:46	0.001	0.008	0.001	0.008	0.003	0.002	0.001	0.001	1.0
TBII #10	22	18:15-09:15	0.001	0.008	0.001	0.004	0.002	0.003	0.001	0.001	1.5
TBII #11	23	09:36-10:51	0.001	0.008	0.001	0.099	0.005	0.048	0.004	0.040	1.0
TBII #12	23	11:12-13:12	0.003	0.016	0.001	0.014	0.011	0.008	0.006	0.004	1.5
TBII #13	23	15:30-17:45	0.001	0.003	0.001	0.018	0.001	0.013	0.001	0.004	1.0
TBII #14	23	22:06-08:36	0.003	0.026	0.002	0.016	0.019	0.012	0.013	0.010	1.0
TBII #15	24	10:07-11:37	0.003	0.026	0.007	0.035	0.011	0.021	0.009	0.015	1.0

TABLE # 6B

Contaminant Levels in Thunder Bay

Units PPM

SITE LOCATION	Date Oct. '77	Monitored Period	Instantaneous Concentration				30-min Maximum Average Concentration		Sample Period Mean Concentration		Scan Time (min.)
			SO2		H2S		SO2	H2S	SO2	H2S	
			Min.	Max.	Min.	Max.					
TBII #16	24	14:40-15:40	0.007	0.011	0.001	0.022	0.010	0.014	0.009	0.008	1.0
TBII #17	24	16:18-08:33	0.003	0.020	0.001	0.017	0.009	0.009	0.005	0.002	1.0
TBII #18	25	11:18-15:48	0.003	0.053	0.001	0.028	0.019	0.009	0.008	0.003	1.0
TBII #19	25	16:10-03:10	0.001	0.121	0.001	0.005	0.110	0.003	0.023	0.002	1.5
TBII #20	27	15:30-04:00	0.001	0.022	0.001	0.024	0.009	0.014	0.001	0.001	1.0
TBII #22	28	11:40-14:40	0.003	0.041	0.001	0.014	0.008	0.004	0.005	0.002	1.0
TBII #24	29	02:59-04:14	0.002	0.013	0.001	0.008	0.006	0.004	0.006	0.003	1.0
TBII #25	29	13:08-16:08	0.006	0.191	0.001	0.047	0.034	0.017	0.019	0.004	1.0
TBII #26	29	16:17-21:47	0.003	0.007	0.001	0.014	0.006	0.004	0.004	0.002	2.0
TBII #27	31	20:45-03:00	0.001	0.002	0.009	0.019	0.001	0.017	0.001	0.012	1.5
TBII #54	22	12:00-16:30	0.001	0.171	0.001	0.001	0.041	0.001	0.023	0.001	2.0
TBII #47	23	10:45-12:05	0.001	0.010	0.018	0.040	0.009	0.034	0.008	0.029	2.0

TABLE # 6C

Contaminant Levels in Thunder Bay

Units PPM

SITE LOCATION	Date Nov. '77	Monitored Period	Instantaneous Concentration				30-min Maximum Average Concentration		Sample Period Mean Concentration		Scan Time (min.)
			SO2		H2S		SO2	H2S	SO2	H2S	
			Min.	Max.	Min.	Max.					
TBII #28	1	12:41-15:26	0.001	0.005	0.001	0.007	0.001	0.008	0.001	0.003	1.0
TBII #29	1	16:29-17:50	0.001	0.005	0.001	0.007	0.001	0.005	0.001	0.003	1.0
TBII #31	2	09:54-13:04	0.001	0.043	0.001	0.035	0.014	0.027	0.006	0.007	1.0
TBII #34	2	20:52-05:07	0.001	0.037	0.007	0.020	0.007	0.014	0.002	0.011	1.5
TBII #35	3	10:36-15:06	0.003	0.027	0.001	0.007	0.013	0.005	0.008	0.004	1.0
TBII #36	3	15:36-18:36	0.002	0.017	0.002	0.029	0.006	0.016	0.004	0.007	1.5
TBII #37	3	19:19-08:04	0.002	0.072	0.001	0.019	0.024	0.014	0.005	0.007	1.0
TBII #38	4	09:17-13:02	0.003	0.263	0.001	0.025	0.092	0.009	0.031	0.004	1.0
TBII #39	5	14:30-07:00	0.001	0.024	0.001	0.015	0.011	0.006	0.003	0.001	1.5
TBII #43	5	16:10-21:40	0.001	0.040	0.002	0.016	0.011	0.011	0.003	0.007	2.5
TBII #44	6	11:47-15:07	0.004	0.006	0.001	0.010	0.006	0.005	0.005	0.002	2.0
TBII #45	6	15:36-17:46	0.001	0.002	0.001	0.015	0.001	0.010	0.001	0.008	2.0
TBII #46	6	18:04-08:04	0.001	0.003	0.001	0.014	0.001	0.010	0.001	0.002	2.0
TBII #50	2	13:40-16:40	0.010	0.090	0.005	0.622	0.086	0.170	0.014	0.093	1.0
TBII #53	3	16:30-08:45	0.001	0.065	0.001	0.017	0.017	0.010	0.001	0.001	3.0

TABLE # 7A

Contaminant Levels in Thunder Bay

Units ppm

SITE LOCATION	Date Oct. '77	Monitored Period	Instantaneous Concentration				30-min. Maximum Average Concentration		Sample Period Mean Concentration		Scan Time (min.)
			O ₃		NO _X		O ₃	NO _X	O ₃	NO _X	
			Min.	Max.	Min.	Max.					
TBII #1	20	17:58-07:58	0.001	0.032	0.001	0.693	0.027	0.620	0.012	0.148	1.0
TBII #2	21	10:13-12:13	0.014	0.034	0.076	0.475	0.028	0.320	0.025	0.228	1.0
TBII #3	21	12:30-13:00	0.008	0.037	0.049	0.129	0.032	0.070	0.032	0.067	1.0
TBII #4	21	13:21-14:21	0.017	0.039	0.017	0.073	0.034	0.042	0.031	0.037	1.0
TBII #5	21	14:40-16:10	0.019	0.046	0.020	0.132	0.037	0.056	0.034	0.051	0.5
TBII #6	21	16:41-19:26	0.009	0.050	0.013	0.276	0.038	0.099	0.030	0.049	0.5
TBII #7	21	19:59-09:29	0.001	0.033	0.118	0.905	0.030	0.650	0.021	0.273	1.0
TBII #8	22	12:06-14:06	0.005	0.029	0.015	1.000	0.026	0.330	0.023	0.225	1.0
TBII #9	22	14:31-17:46	0.001	0.031	0.001	1.000	0.028	0.490	0.024	0.280	1.0
TBII #10	22	18:15-09:15	0.001	0.030	0.057	1.000	0.028	1.000	0.014	0.726	1.5
TBII #11	23	09:36-10:51	0.001	0.017	0.056	0.949	0.006	0.670	0.005	0.447	1.0
TBII #12	23	11:12-13:12	0.004	0.030	0.107	0.837	0.011	0.490	0.018	0.358	1.5
TBII #13	23	15:30-17:45	-	-	0.036	0.684	-	0.390	-	0.278	1.0
TBII #14	23	22:06-08:36	0.001	-	0.435	0.926	0.040	0.926	-	0.883	1.0
TBII #15	24	10:07-11:37	0.001	0.530	0.069	0.927	0.240	0.380	0.136	0.327	1.0

TABLE # 7B

Contaminant Levels in Thunder Bay

Units PPM

SITE LOCATION	Date Oct. '77	Monitored Period	Instantaneous Concentration				30-min. Maximum Average Concentration		Sample Period Mean Concentration		Scan Time (min.)
			O ₃		NO _x		O ₃	NO _x	O ₃	NO _x	
			Min.	Max.	Min.	Max.					
TBII #16	24	14:40-15:40	0.008	0.037	0.027	0.242	0.026	0.084	0.024	0.082	1.0
TBII #17	24	16:18-08:33	0.001	0.046	0.017	0.907	0.041	0.590	0.015	0.227	1.0
TBII #18	25	11:18-15:48	0.006	0.043	0.010	0.097	0.031	0.052	0.024	0.032	1.0
TBII #19	25	16:19-03:19	0.011	0.032	0.018	0.342	0.030	0.074	0.024	0.043	1.5
TBII #20	27	15:30-04:00	0.010	0.039	0.005	0.265	0.038	0.094	0.034	0.037	1.0
TBII #22	28	11:40-14:40	0.020	0.044	0.005	0.081	0.041	0.028	0.034	0.015	1.0
TBII #24	29	02:59-04:14	0.001	0.015	0.029	0.817	0.008	0.230	0.007	0.190	1.0
TBII #25	29	13:08-16:08	0.021	0.034	0.001	0.051	0.032	0.028	0.030	0.004	1.0
TBII #26	29	16:17-21:47	0.017	0.033	0.001	0.039	0.033	0.024	0.028	0.001	2.0
TBII #27	31	20:45-03:00	0.001	0.021	0.003	0.551	0.019	0.049	0.015	0.023	1.5

TABLE # 7C

Contaminant Levels in Thunder Bay

Units PPM

SITE LOCATION	Date Nov. '77	Monitored Period	Instantaneous Concentration				30-min. Maximum Average Concentration		Sample Period Mean Concentration		Scan Time (min.)
			O ₃		NO _x		O ₃	NO _x	O ₃	NO _x	
TBII #28	1	12:11-15:26	0.004	0.30	0.005	0.102	0.025	0.022	0.021	0.010	1.0
TBII #29	1	16:29-17:59	0.004	0.018	0.003	0.306	0.014	0.056	0.013	0.031	1.0
TBII #31	2	09:54-13:04	0.001	0.030	0.001	0.321	0.017	0.075	0.011	0.037	1.0
TBII #34	2	20:52-05:07	0.001	0.024	0.001	0.671	0.012	0.260	0.003	0.127	1.5
TBII #35	3	10:36-15:06	0.001	0.039	0.005	0.341	0.033	0.120	0.020	0.044	1.0
TBII #36	3	15:36-18:36	0.008	0.036	0.006	0.202	0.034	0.062	0.027	0.039	1.5
TBII #37	3	19:19-09:04	0.001	0.026			0.024		0.017		1.0
TBII #38	4	09:17-13:02	0.003	0.031			0.029		0.018		1.0
TBII #39	5	14:30-02:00	0.001	0.032			0.029		0.008		1.5
TBII #43	5	16:10-21:40		NO	DATA	MONITORED					2.5
TBII #44	6	11:47-15:07		NO	DATA	MONITORED					2.0
TBII #45	6	15:36-17:46		NO	DATA	MONITORED					2.0
TBII #46	6	18:04-08:04		NO	DATA	MONITORED					2.0
TBII #50	2	13:40-16:40	0.001	0.047	0.046	0.176	0.017	0.086	0.013	0.072	1.0
TBII #53	3	16:30-08:45	0.001	0.045	0.013	0.064	0.024	0.050	0.014	0.023	3.0

TABLE 8A

HI-VOL ANALYSIS FOR THUNDER BAY, 1977

SITE	HI-VOL	SITE LOCATION	DATE	MICROGRAMS/m ³					Sample Time (Hrs.)	WIND	COMMENTS
I.D.	NUMBER 60---		OCT.	T.S.P.	SO ₄ ⁼	Cl ⁻	Total Carbon	Free Carbon		DIR. Km/Hr	& REMARKS
1	137	Dow Chemical (D.C.)	22	107	5.2	1.1	14.88	4.11	24	WSW	
2	139	Canadian Car (C.C.)		86	8.7	2.0	11.29	2.69	"	9	Vanadium - 0.017 ug/m ³
3	138	M. Trocheri (M.T.)		50	4.1	1.2	11.00	1.14	"		Vanadium - N.D.
4	136	St. Anne's School (S.A.S.)		34	3.4	0.6	7.11	1.26	"		Vanadium - 0.017 ug/m ³
5	135	Trailer Park (T.P.)		18.	2.7	0.5	4.45	0.33	"		
		Daily Average		59	4.8		9.74				
1	142	D.C.	23-24	72	5.3	0.8	16.32	2.48	"	SW	
2	143	C.C.		156	6.9	2.1	23.89	4.54	"	6	Vanadium - 0.026 ug/m ³
3	141	M.T.		54	4.3	0.9	12.51	2.17	"		Vanadium - N.D.
4	144	S.A.S.		56	4.3	0.9	9.91	1.22	"		Vanadium - 0.017 ug/m ³
5	140	T.P.		20	2.3	0.5	4.74	0.47	"		
		Daily Average		72	4.6		13.47				
1	147	D.C.	24-25	141	14.6	1.4	26.26	4.70	"	SE	
2	148	C.C.		195	18.2	0.9	39.05	6.60	"	6	
3	146	M.T.		273	19.7	3.4	64.41	7.93	8		
4	149	S.A.S.		97	13.7	0.6	20.61	2.25	24		

TABLE 8B

HI-VOL ANALYSIS FOR THUNDER BAY, 1977

SITE	HI-VOL	SITE LOCATION	DATE	MICROGRAMS/m ³					Sample Time (Hrs.)	WIND	COMMENTS
I.D.	NUMBER 60		OCT.	T.S.P.	SO ₄ ⁼	Cl ⁻	Total Carbon	Free Carbon		DIR. Km/Hr	& REMARKS
5	145	P.P.	24-25	68	9.2	0.6	12.75	2.69	24	SE	
		DAILY AVERAGE		155	15.1		32.61			6	
1	152	D.C.	25-26	337	15.5	4.3	22.31	3.63	"	SW	
2	153	C.C.		264	16.3	5.4	23.85	3.64	"	19	
3	151	M.T.		52	6.3	0.4	7.42	2.41	"		
4	154	S.A.S.		64	7.4	0.5	9.04	0.87	"		
5	150	T.P.		28	6.6	0.4	5.21	0.83	"		
		DAILY AVERAGE		149	10.4		13.56				
1	160	D.C.	26-27	410	6.3	3.3	41.96	8.08	"	W	
2	155	C.C.		354	7.2	2.9	38.90	7.17	"	9	
3	156	M.T.		168	5.4	1.7	33.41	6.63	"		
4	157	S.A.S.		102	4.0	0.9	15.12	2.45	"		
5	159	T.P.		84	3.7	1.0	17.17	5.98	"		
		Daily Average		224	5.3		29.31				
1	162	D.C.	28-29	336	6.4	2.6	42.47	7.76	"	SW	
2	164	C.C.		375	10.3	3.4	55.72	10.11	"	4	

TABLE 8C

HI-VOL ANALYSIS FOR THUNDER BAY, 1977

SITE	HI-VOL	SITE LOCATION	DATE	MICROGRAMS/m ³					Sample Time (Hrs.)	WIND	COMMENTS
I.D.	NUMBER 60 _____		Oct/Nov.	T.S.P.	SO ₄ ⁼	Cl ⁻	Total Carbon	Free Carbon		DIR.	& REMARKS
3	161	M.T.	28-29	101	6.9	1.4	23.30	5.06	24	SW	
4	163	S.A.S.		122	7.2	1.2	20.10	4.03	"	4	
5	165	T.P.		74	3.4	0.3	7.06	3.26	"		
		DAILY AVERAGE		202	6.8		29.73				
1	167	D.C.	29-30	31	4.6	0.3	8.05	1.79	"	E	
2	169	C.C.		52	6.9	0.5	10.14	1.82	"	11	Vanadium - N.D.
3	166	M.T.		97	7.9	3.6	16.19	4.50	"		Vanadium - 0.017 ug/m ³
4	168	S.A.S.		37	5.2	0.4	8.97	0.56	"		
5	173	T.P.		34	7.3	0.3	5.25	2.72	"		
		DAILY AVERAGE		50	6.4		9.72		"		
1	170	D.C.	31-1	44	7.4	0.3	3.75	0.87	"	SE	
2	174	C.C.		69	11.7	0.3	9.52	1.54	"	4	
3	178	M.T.		36	11.5	0.4	10.19	2.03	"		
4	180	S.A.S.		38	8.6	0.3	10.53	4.77	"		
5	177	T.P.		29	8.0	0.4	8.36	4.88	"		
		DAILY AVERAGE		43	9.4		8.47				

TABLE 8D

HI-VOL ANALYSIS FOR THUNDER BAY, 1977


SITE	HI-VOL	SITE LOCATION	DATE	MICROGRAMS/m ³					Sample Time (Hrs.)	WIND	COMMENTS
I.D.	NUMBER 60		NOV.	T.S.P.	SO ₄ ⁼	Cl ⁻	Total Carbon	Free Carbon		DIR.	& REMARKS
1	179	D.C.	1-2	120	11.1	1.0	0.07	2.05	24	W	
2	185	C.C.		148	9.3	2.3	36.29	9.64	"	4	
3	183	M.T.		111	7.4	1.7	22.62	5.69	"		
4	186	S.A.S.		81	7.3	1.1	17.17	5.21	"		
5	182	T.P.		53	5.2	0.5	12.31	5.75	"		
		DAILY AVERAGE		103	1.4		19.68				
1	184	D.C.	2-3	87	6.7	1.1	18.00	3.99	"	S	
2	190	C.C.		116	8.4	2.4	24.72	6.32	"	4	
3	188	M.T.		10	1.4	0.3	3.36	0.36	"		
4	192	S.A.S.		38	6.6	2.9	16.86	7.15	"		
5	189	T.P.		38	4.1	0.6	9.70	4.01	"		
		Daily Average		58	5.4		14.53				
1	187	D.C.	3-4	108	8.9	2.6	14.13	3.60	"	SW	
2	196	C.C.		109	7.9	2.9	19.23	2.17	14	9	
3	194	M.T.		26	4.6	0.6	6.12	2.73	24		
4	197	S.A.S.		32	4.6	0.5	7.54	4.64	"		

TABLE 8E

HI-VOL ANALYSIS FOR THUNDER BAY, 1977

SITE	HI-VOL	SITE LOCATION	DATE	MICROGRAMS/m ³					Sample Time (Hrs.)	WIND	COMMENTS
I.D.	NUMBER 60____		Nov.	T.S.P.	SO ₄ ⁼	Cl ⁻	Total Carbon	Free Carbon		DIR.	& REMARKS
5	193	P.P.	3-4	20	2.5	0.3	5.64	2.37	24	SW	
		DAILY AVERAGE		59	1.1		10.53				
1	195	D.C.	4-5	35	6.3	1.7	14.69	3.67	"	S	
2	201	C.C.		49	5.4	0.6	12.24	2.01	"	4	
3	199	M.T.		38	5.7	0.9	9.87	3.00	"		
4	202	S.A.S.		55	5.7	1.1	11.09	5.65	"		
5	198	T.P.		25	3.8	0.4	6.67	2.24	"		
		Daily Average		40	5.4		10.91				
1		D.C.	5-6	-	-	-	-	-	-		
2	207	C.C.		64	10.0	2.1	17.17	2.29	"	SW	
3	205	M.T.		52	8.0	1.7	13.54	4.07	"	4	
4	203	S.A.S.		-	6.2	1.1	11.72	3.48	"		
5	204	P.P.		26	3.8	0.4	7.25	2.37	"		
		DAILY AVERAGE		47	7.0		9.94				
		OVERALL AVERAGE		98.5	7.4	1.4	16.8				

9.0 APPENDIX

(a) Figures:

#1	H ₂ S, SO ₂ & O ₃ Concentration versus Time for Site	#2
#2	"	" #4
#3	"	" #7
#4	"	" #11
#5	"	" #15
#6	"	" #17
#7	"	" #19
#8	"	" #27
#9	"	" #37
#10	"	" #38
#11	"	" #39
#12	H ₂ S & SO ₂ Concentration versus Time for Site	#46
#13	H ₂ S, SO ₂ & O ₃ Concentration versus Time for Site	#47
#14	"	" #50
#15	"	" #53

(b) Maps:

#4	H ₂ S Wind-Rose for Site	#2
#5	"	" #37
#6	"	" #46
#7	SO ₂	" #6
#8	"	" #7
#9	"	" #17
#10	"	" #18
#11	"	" #19
#12	"	" #31
#13	"	" #37
#14	"	" #38
#15	"	" #46
#16	NO _x	" #17

THUNDER BAY 11 #2

10:13 OCT 21 1977

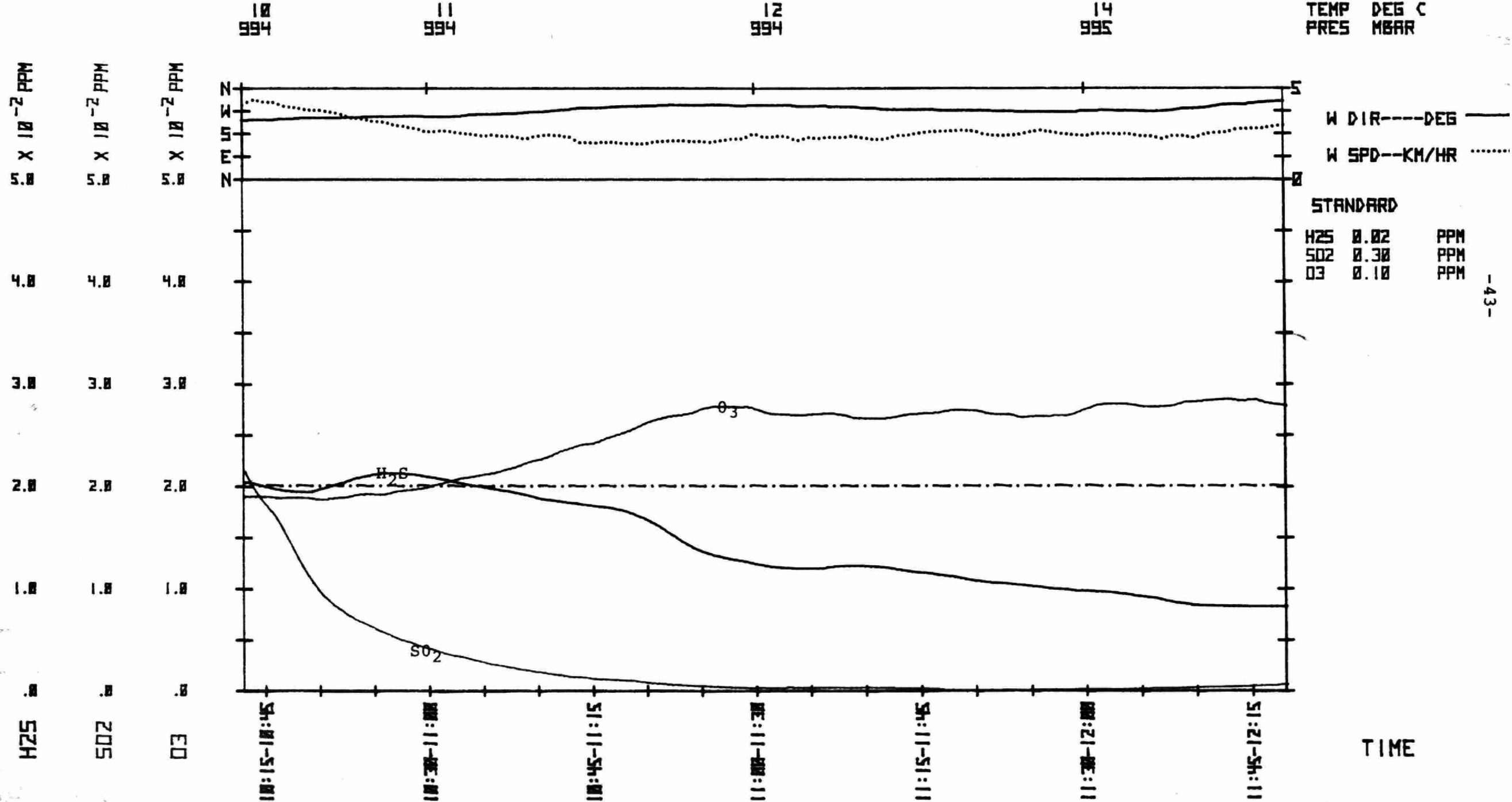
SCAN= 60 SEC

AVE= 30

MIN

HWY #618;(33025-53578), 1.2KM, 45 DEG/SOURCE

Fig. 1



THUNDER BAY 11 #4

13:21 OCT 21 1977

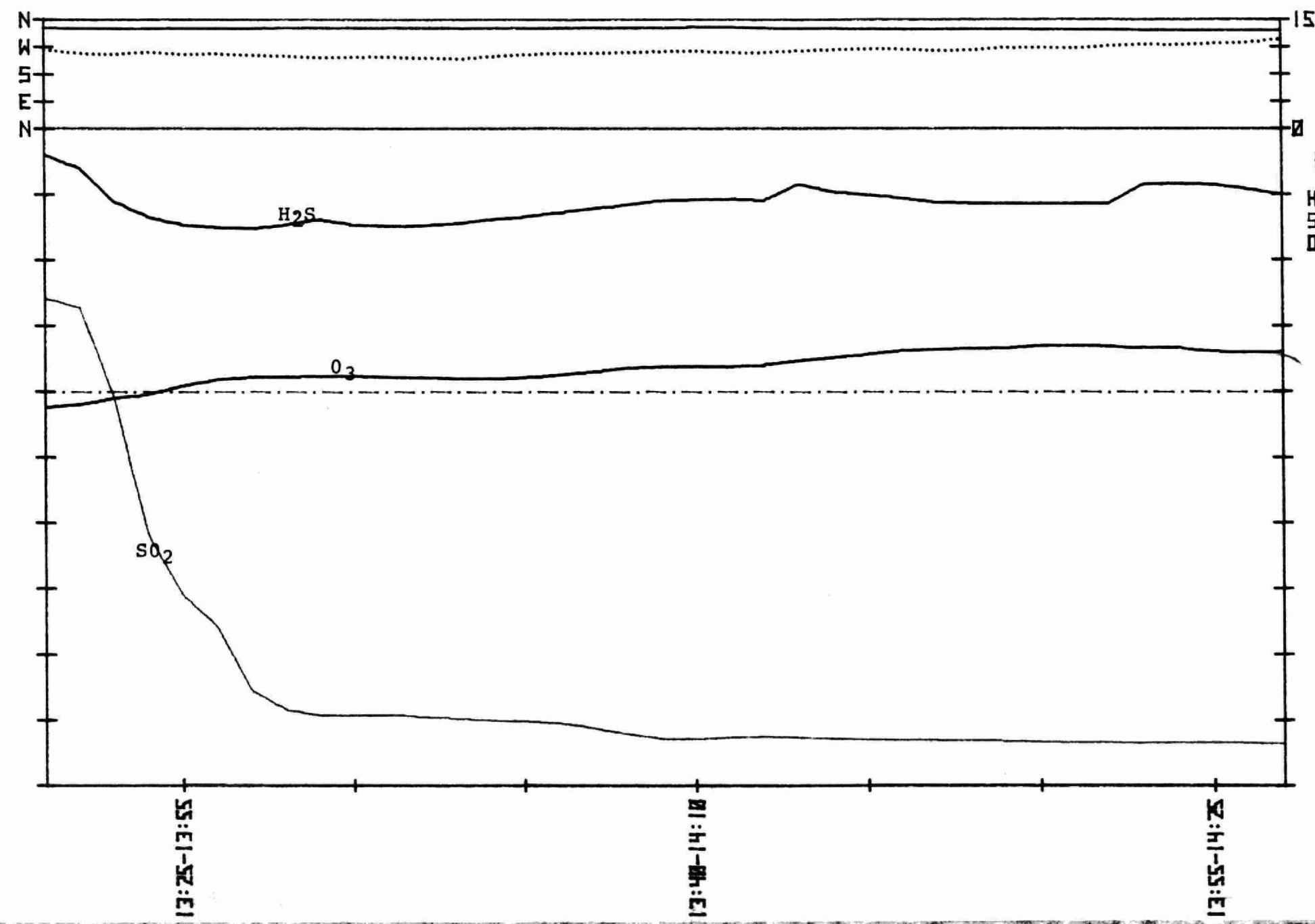
SCAN= 60 SEC

AVE= 30 MIN

HWY #618;(32900-535680)/0.6KM/ 220 DEG/SOURCE

Fig. 2

$\times 10^{-2}$ PPM
 $\times 10^{-1}$ PPM
 $\times 10^{-2}$ PPM
 H2S
 SO2
 O3



W DIR----DEG
 W SPD--KM/HR
 STANDARD
 H2S 0.02 PPM
 SO2 0.30 PPM
 O3 0.10 PPM

TIME

THUNDER BAY 11 #7

19:59 OCT 21 1977

SCAN= 60

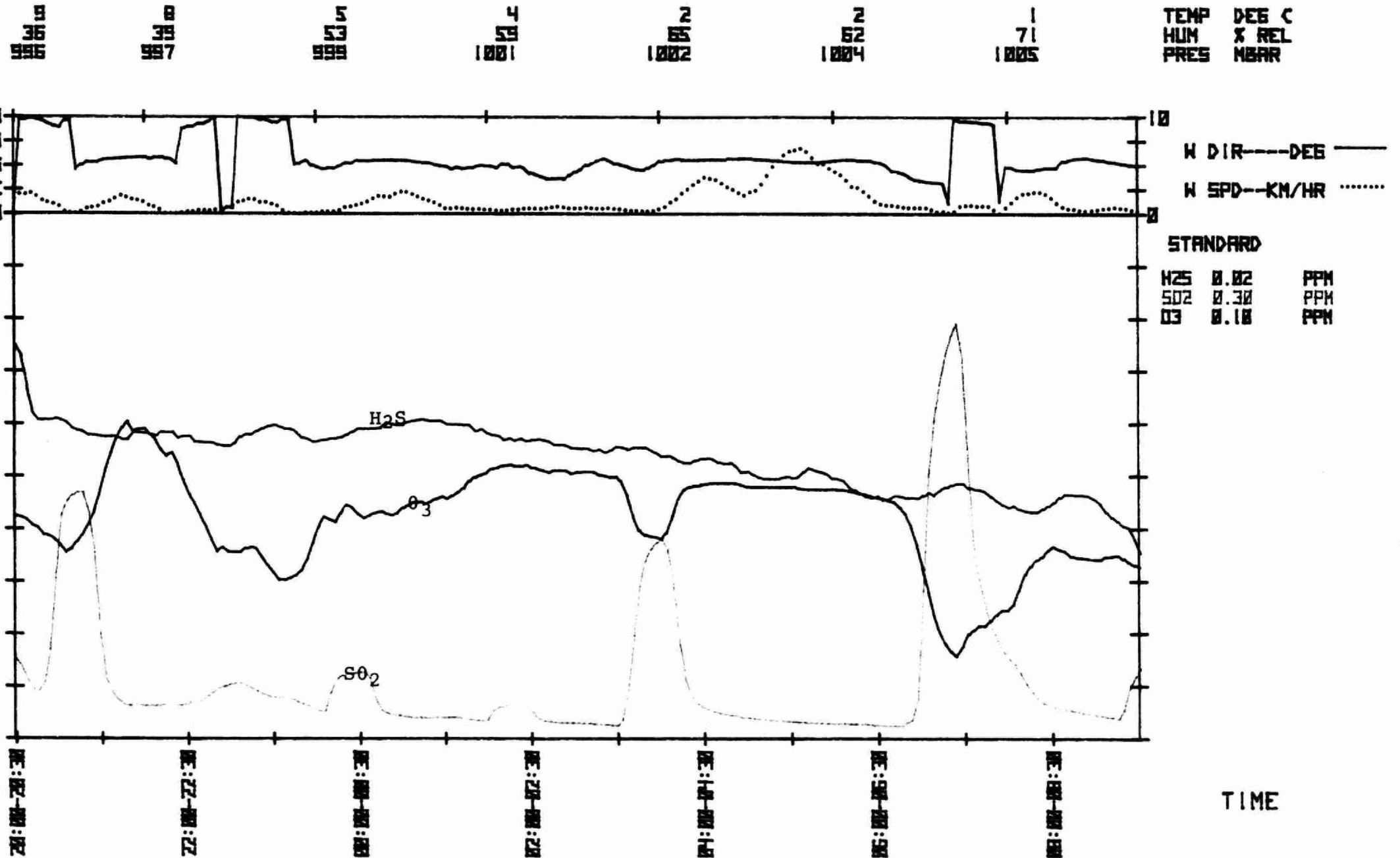
SEC

AVE= 30

MIN

MT. MCKAY SKI AREA; (32950-53570), 0.7KM, 135 DEG/SOURCE

Fig. 3



THUNDER BAY II #11

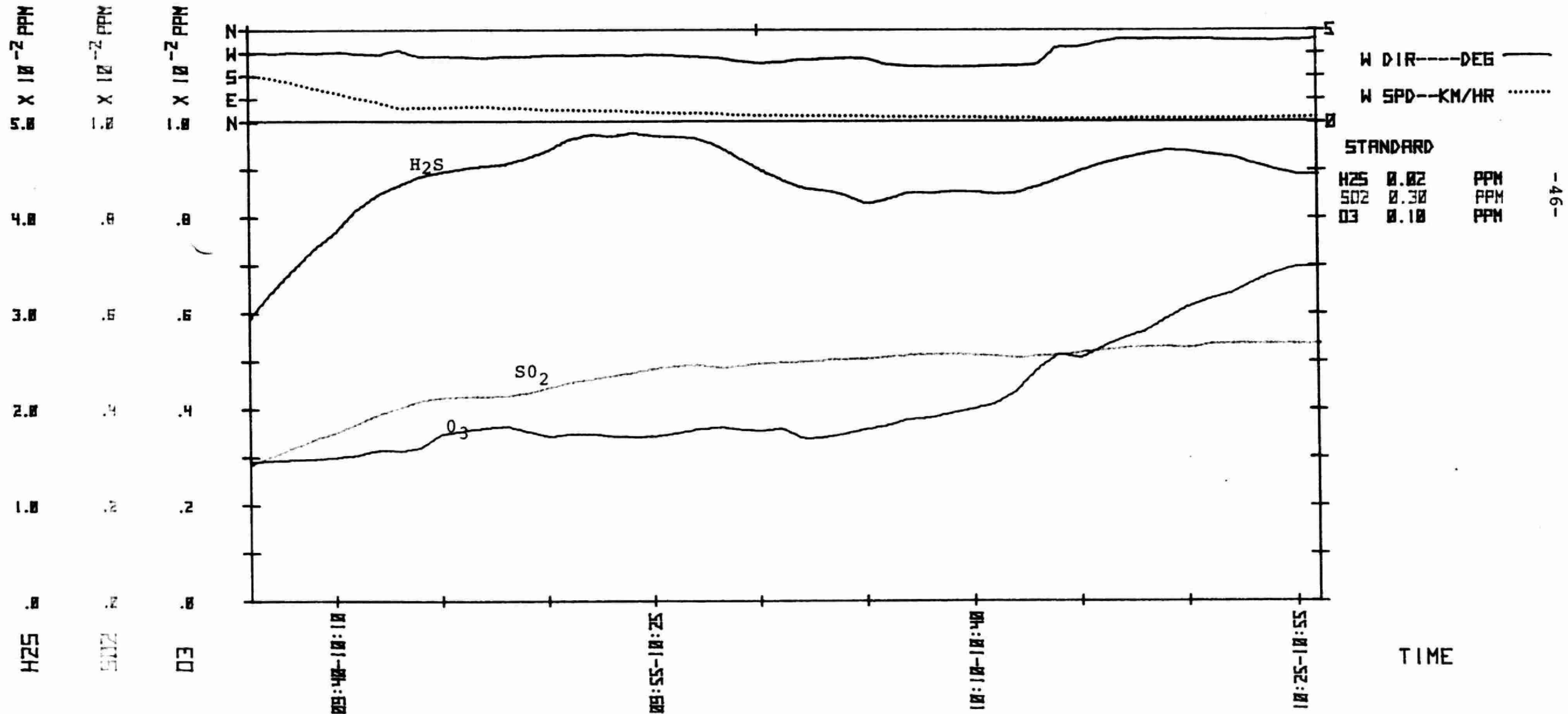
Fig. 4

09:36 OCT 23 1977 SCAN= 60 SEC AVE= 30 MIN
 MAIN GATE OF G.L.P.P.; (32905-43579), 0.5KM, SDE6/SOURCE

0.011
 -1
 95
 1009

0.020
 1
 89
 1009

SRAD W/CM2
 TEMP DEG C
 HUM % REL
 PRES MBAR



THUNDER BAY 11 #15

10:07 OCT 24 1977

SCAN= 60 SEC AVE= 30 MIN

100M E OF G.L.P.P. MILL GATE; (34040-53713), 0.4KM, 330 DEG/SOURCE

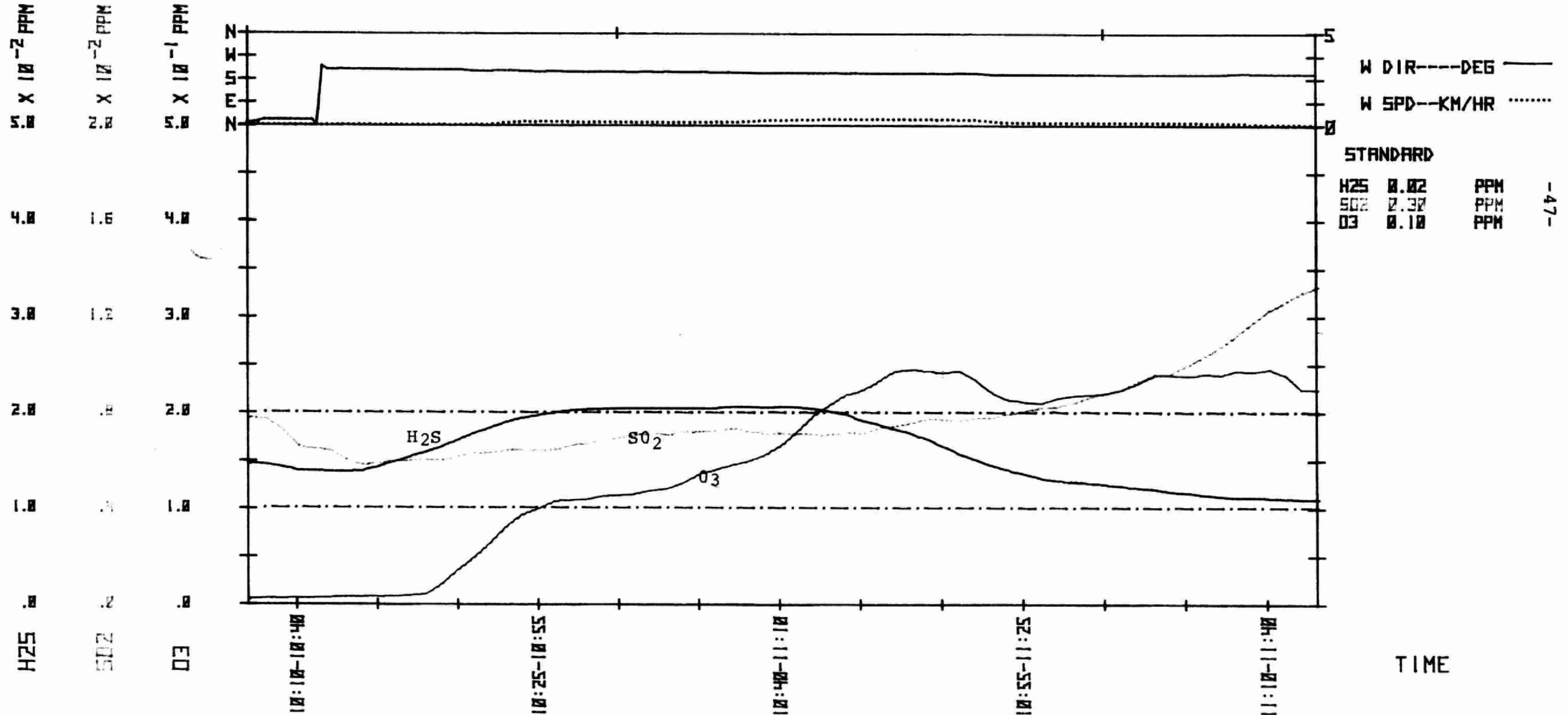
Fig. 5

0.007
7
82
997

0.009
9
76
997

0.009
11
69
997

SRAD W/CM2
TEMP DEG C
HUM % REL
PRES MBAR



THUNDER BAY 11 #17

16:18 OCT 24 1977

SCAN= 60 SEC AVE= 30 MIN

CAN CAR LTD PROPERTY; (32945-53583), 1KM, 20 DEG/SOURCE

Fig. 6

0.010
12
70
994

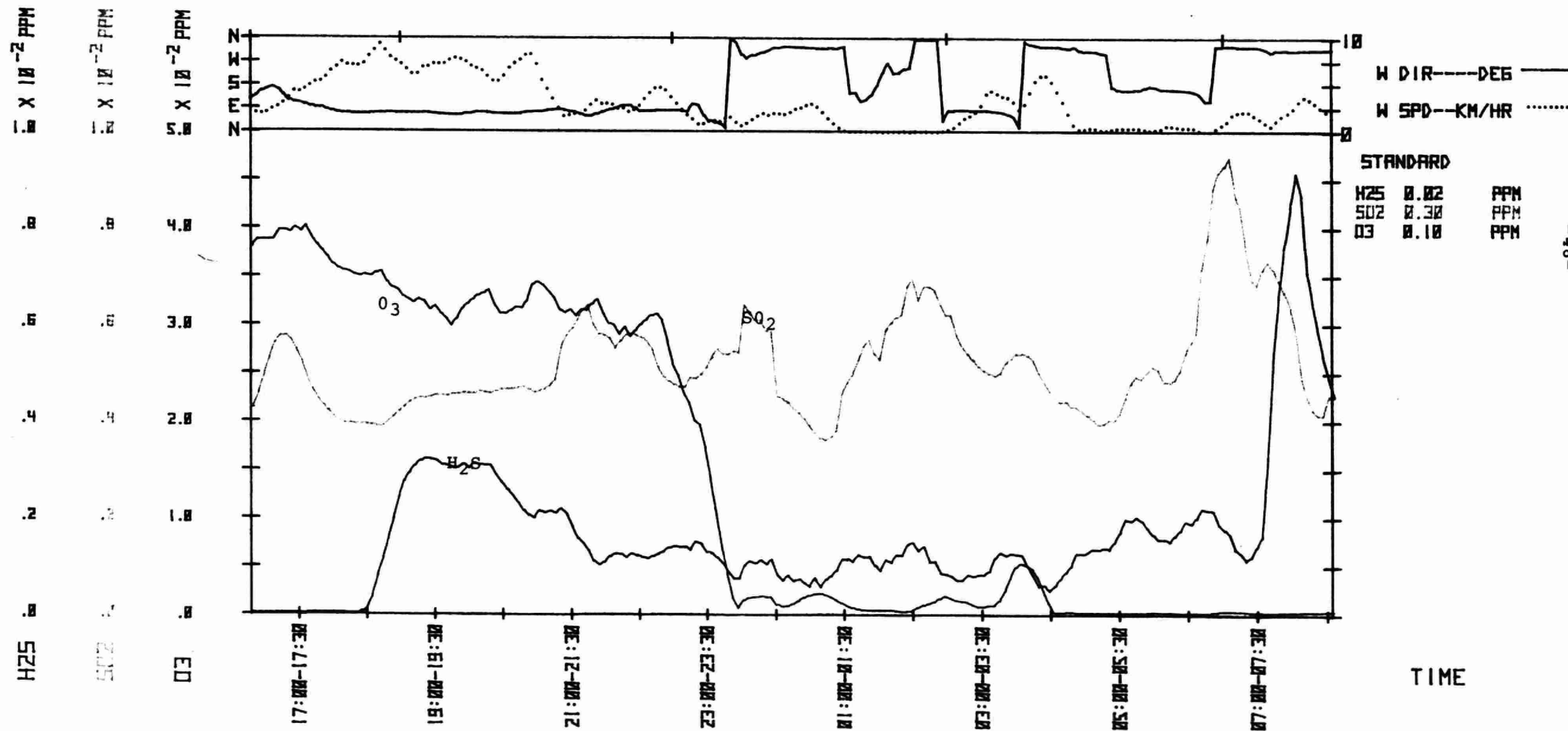
0.000
9
91
993

0.000
10
93
992

0.000
11
77
990

0.000
11
79
990

SRAD W/CM2
TEMP DEG C
HUM % REL
PRES MBAR



THUNDER BAY 11 #19

Fig. 7

16:19 OCT 25 1977

SCAN= 90

SEC

AVE= 30

MIN

C.N.R.A. RECREATION RINK;(33055-53584)/1.7KM/ 50 DEG/SOURCE

0.013
14
70
984

0.006
13
72
984

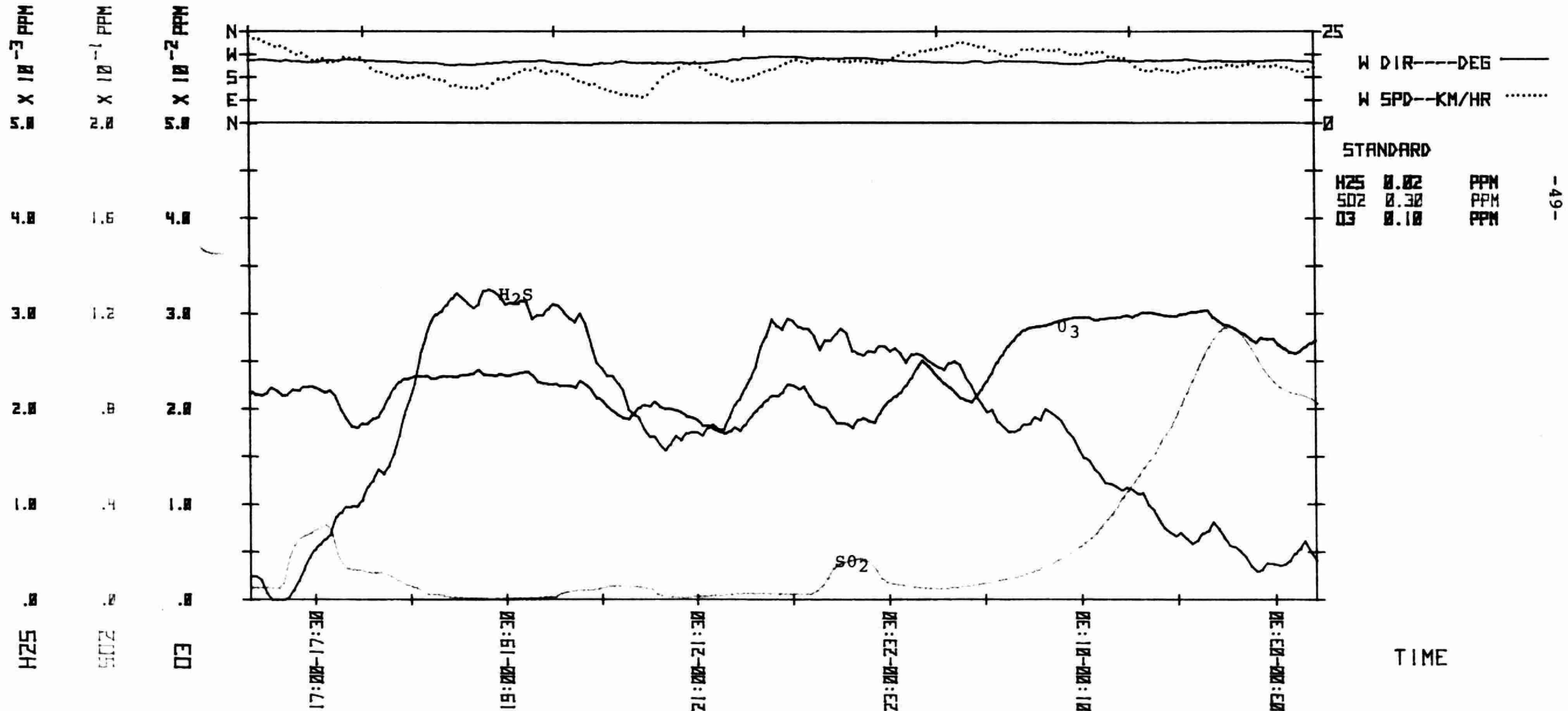
0.000
12
75
982

0.000
12
76
980

0.000
12
75
980

0.000
13
71
980

SRAD W/CM2
TEMP DEG C
HUM % REL
PRES MBAR



THUNDER BAY 11 #27

20:45 OCT 31 1977

SCAN= 90

SEC

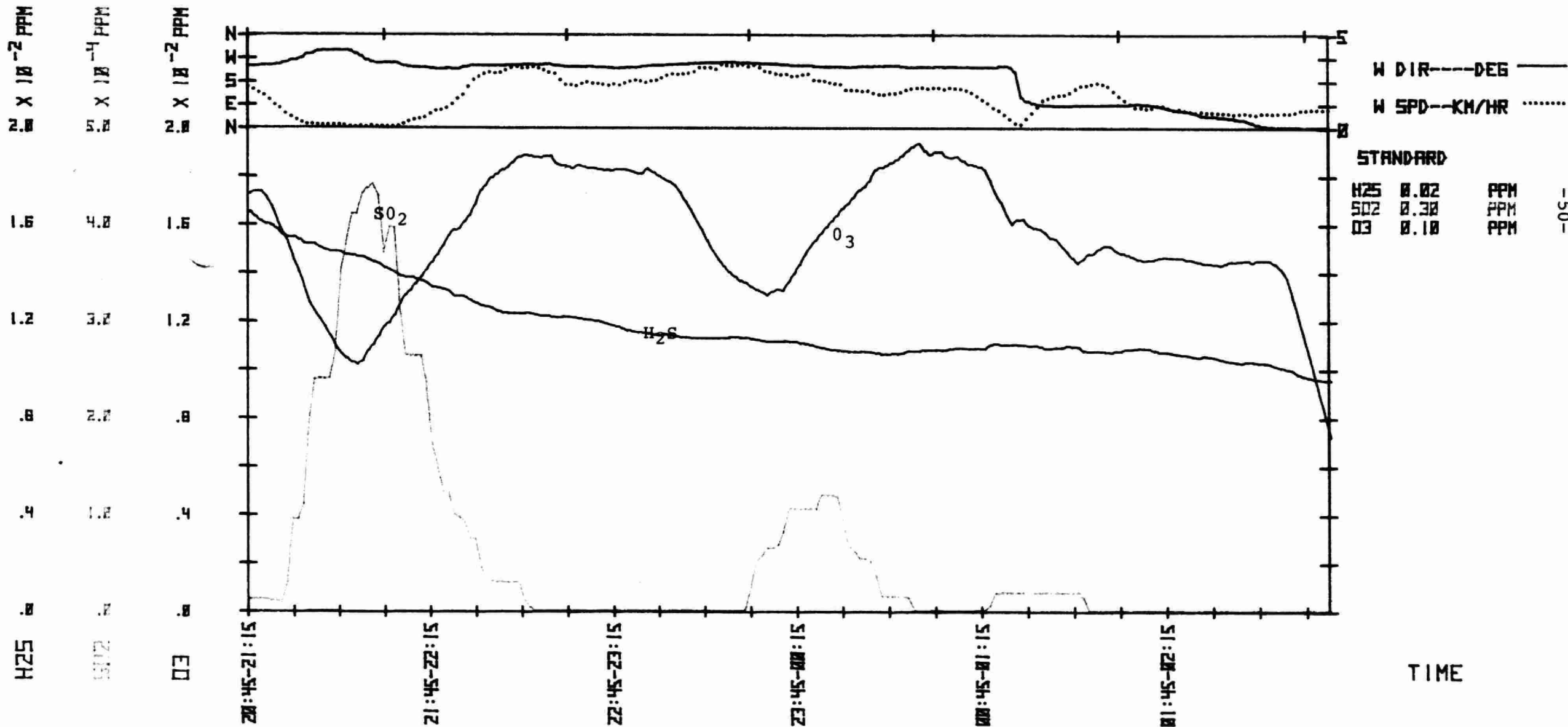
AVE= 30

MIN

C.N.R.A. RECREATION RINK;(33050-53583)/1.7KM/ 55 DEG/SOURCE

Fig. 8

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	SRAD	W/CM2
11	11	11	11	10	8	7	TEMP	DEG C	
100	100	100	100	100	100	100	HUM	% REL	
983	983	984	984	985	985	986	PRES	MBAR	



THUNDER BAY 11 #37

Fig. 9

19:19 NOV 3 1977

SCAN= 60

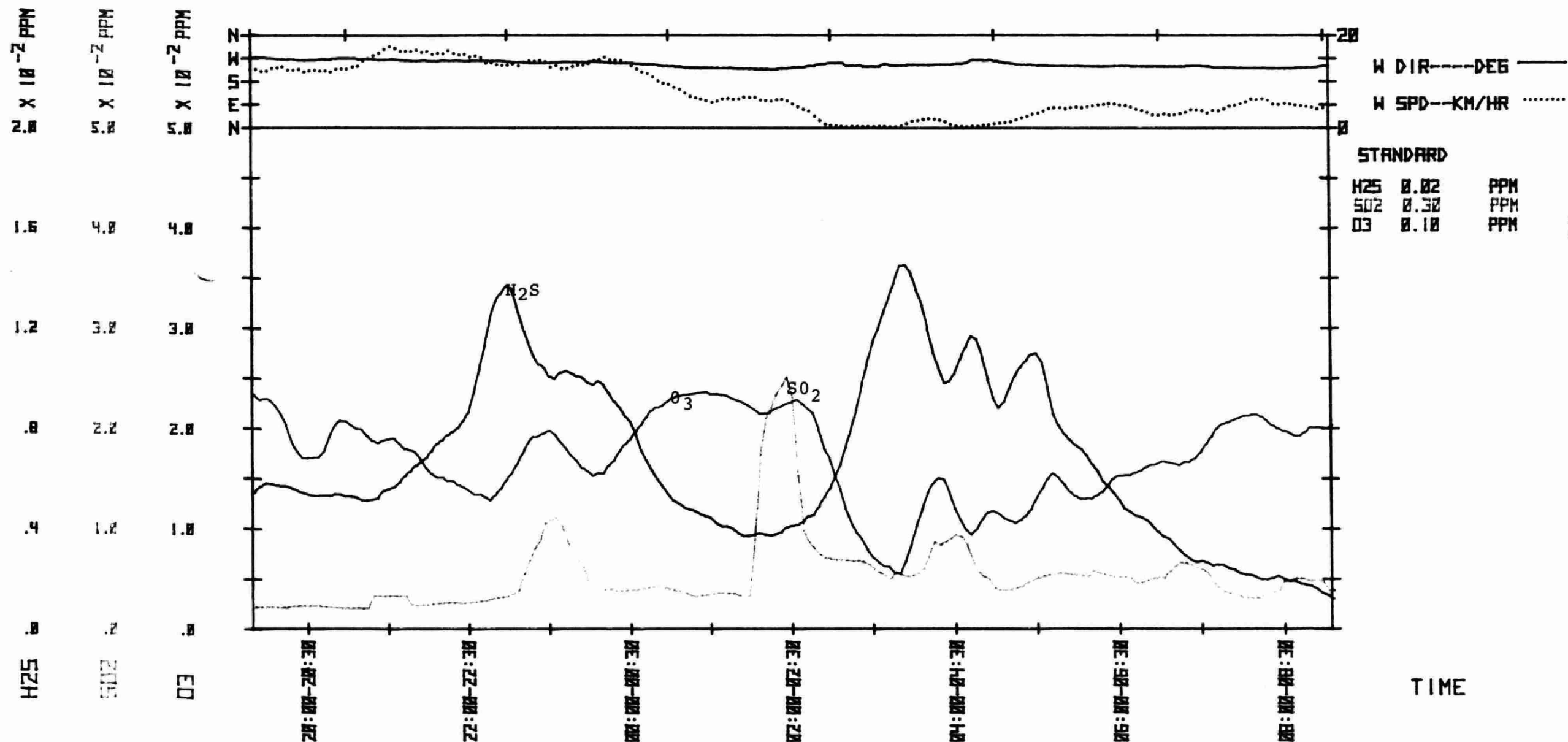
SEC

AVE= 30

MIN

C.N.R.A. RECREATION RINK; (33050-53503), 1.7KM, 55 DEG/SOURCE

9	8	7	5	4	2	2	4TEMP	DEG C
40	46	57	60	70	80	75	69HUM	% REL
995	997	999	1001	1003	1005	1007	1009PRES	MBAR



THUNDER BAY 11 #38

Fig. 10

09:17 NOV 4 1977

SCAN= 60

SEC

AVE= 30

MIN

INDIAN RESERVE LOOKOUT RD.; (33170-53571); 2.6KM, 110 DEG/SOURCE

0.010
6
65
1009

0.021
9
50
1010

0.026
10
45
1010

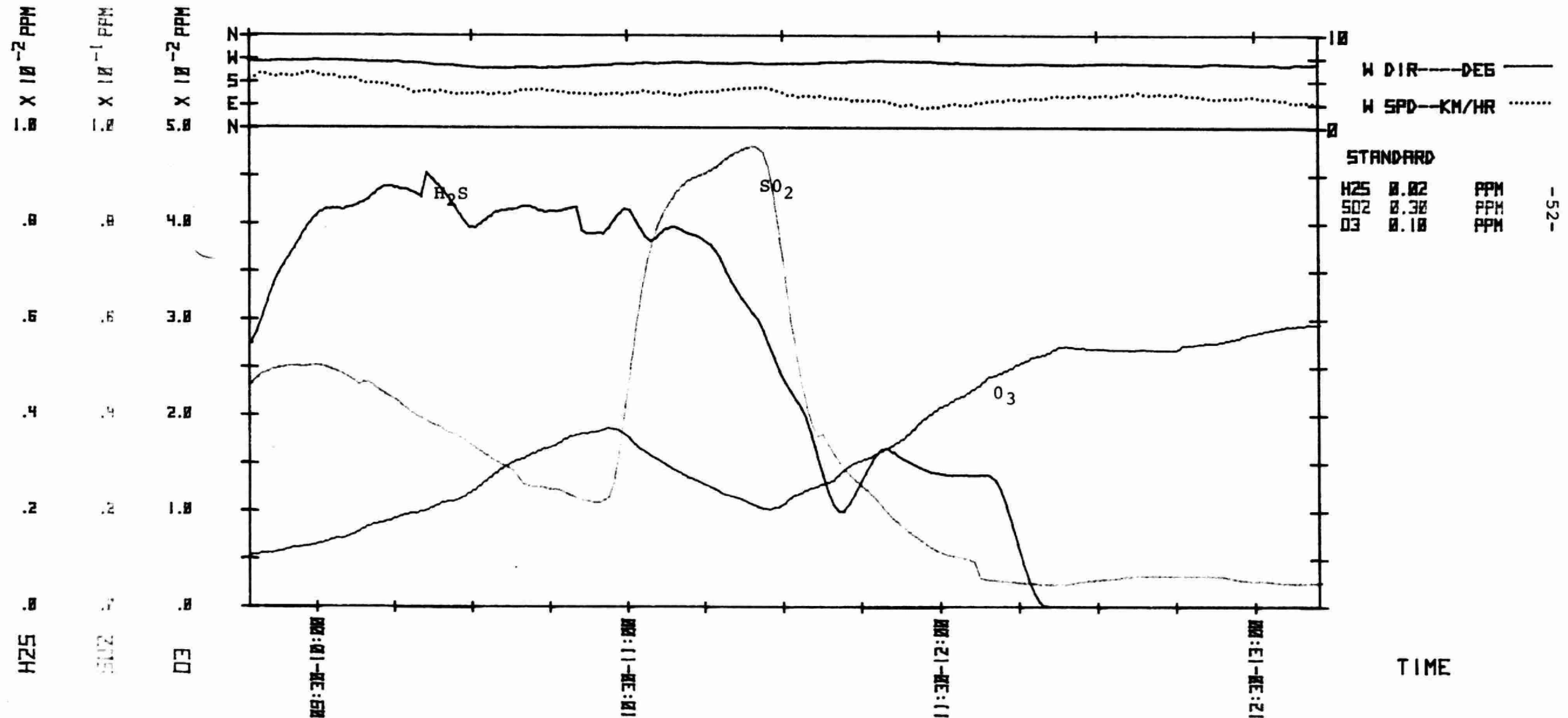
0.029
11
44
1010

0.032
13
36
1010

0.035
14
32
1010

0.036
14
30
1010

SRAD W/CM2
TEMP DEG C
HUM % REL
PRES MBAR



THUNDER BAY 11 #39

Fig. 11

14:30 NOV 5 1977

SCAN= 90 SEC

AVE= 30

MM

BROADWAY ST. & HWY #61/(32835-53579)/0.9KM/ 315 DEG/SOURCE

10
41

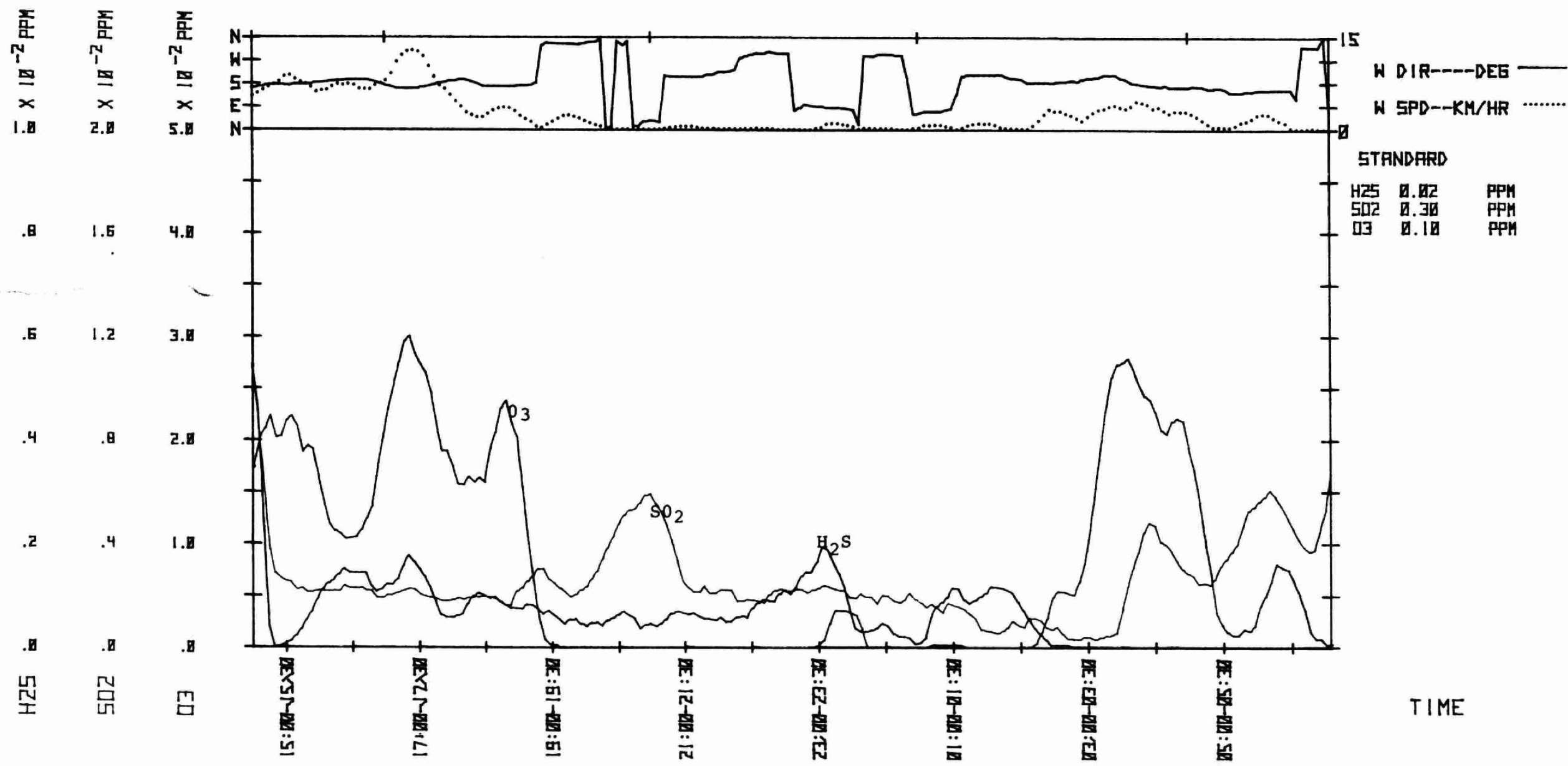
6
58

2
85

-0
99

5
98

TEMP DEG C
HUM % REL



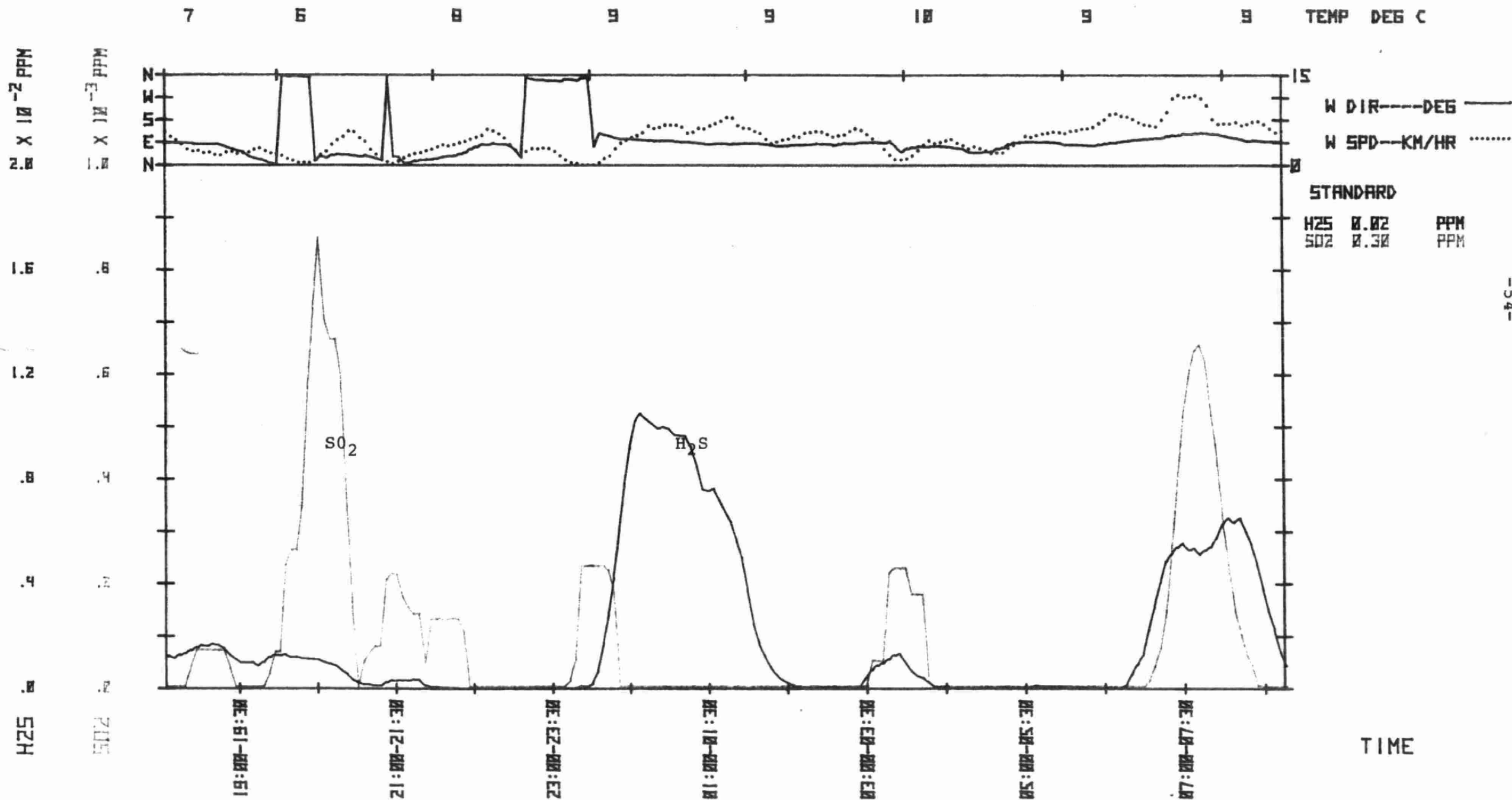
THUNDER BAY 11 #46

18:04 NOV 6 1977

SCAN= 120 SEC AVE= 30 MIN

BROADWAY ST. & HWY #61; (32835-53580), 1KM, 315 DEG/SOURCE

Fig. 12



THUNDER BAY 11 #47

Fig. 13

10:45 OCT 23 1977

SCAN= 120 SEC

AVE= 30

MIN

MT. MCKAY RD. (32920-53567); 0.7KM & 100 DEG / SOURCE

5.0 X 10⁻² PPM
1.0 X 10⁻² PPM
2.0 X 10⁻² PPM

4.0 .8 1.6

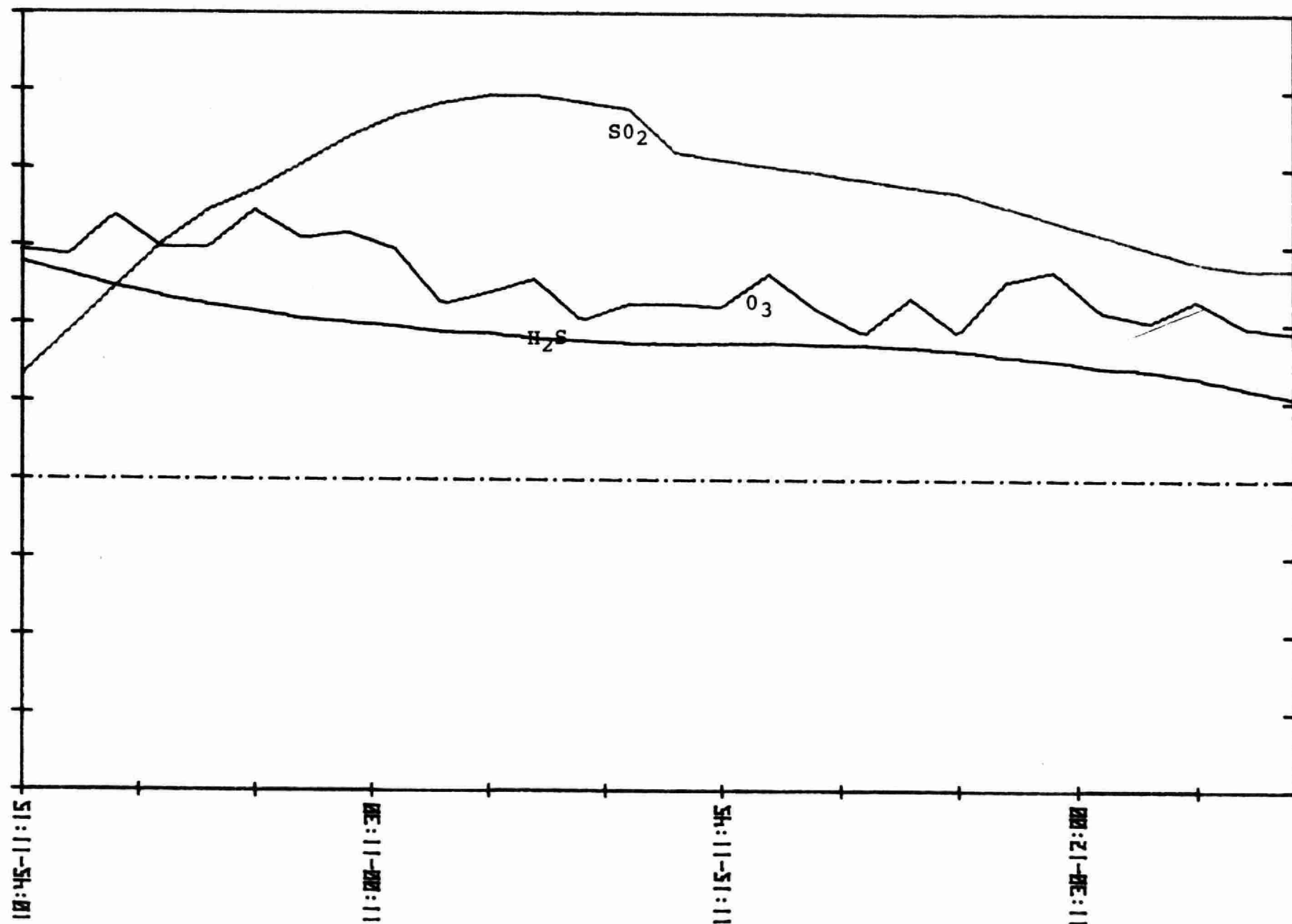
3.0 .6 1.2

2.0 .4 .8

1.0 .2 .4

.0 .0 .0

H2S
SO2
O3



STANDARD

H ₂ S	0.02	PPM
SO ₂	0.30	PPM
O ₃	0.10	PPM

TIME

THUNDER BAY 11 #50

13:40 NOV 2 1977

SCAN= 60

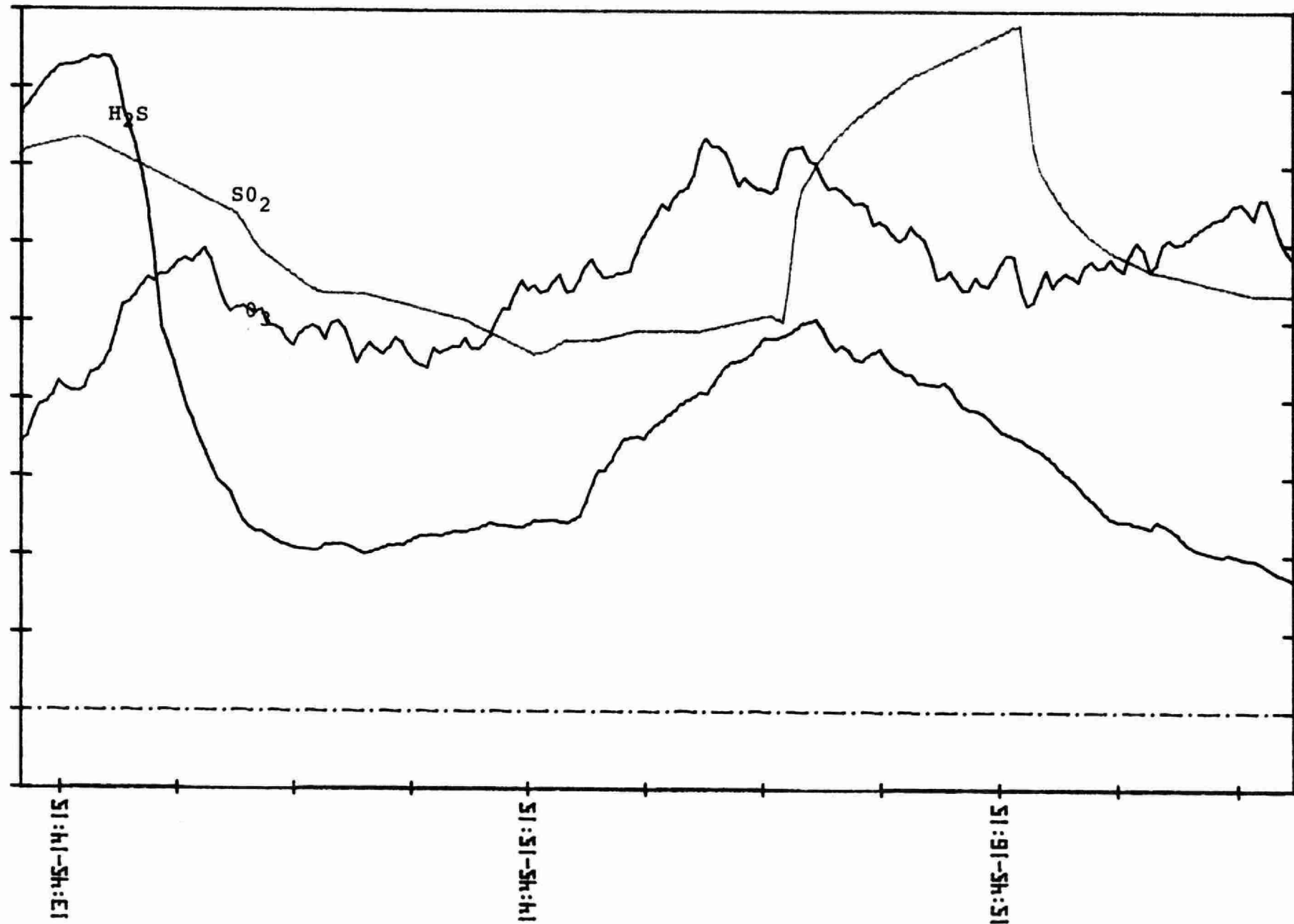
SEC

AVE= 30

MIN

BROADWAY & NEEBING (32900-53501); 0.8KM & 350 DEG / SOURCE

Fig. 14



STANDARD

H2S	0.02	PPM
SO2	0.30	PPM
O3	0.10	PPM

THUNDER BAY 11 #53

Fig. 15

16:30 NOV 3 1977

SCAN= 180 SEC

AVE= 30

MIN

HRCBUOIL CONST.(32985-53579); 1.1 KM & 45 DEG / SOURCE

10-2 PPM
X
2.0

10-2 PPM
X
2.0

10-2 PPM
X
5.0

1.6

1.6

4.0

1.2

1.2

3.0

.8

.8

2.0

.4

.4

1.0

.0

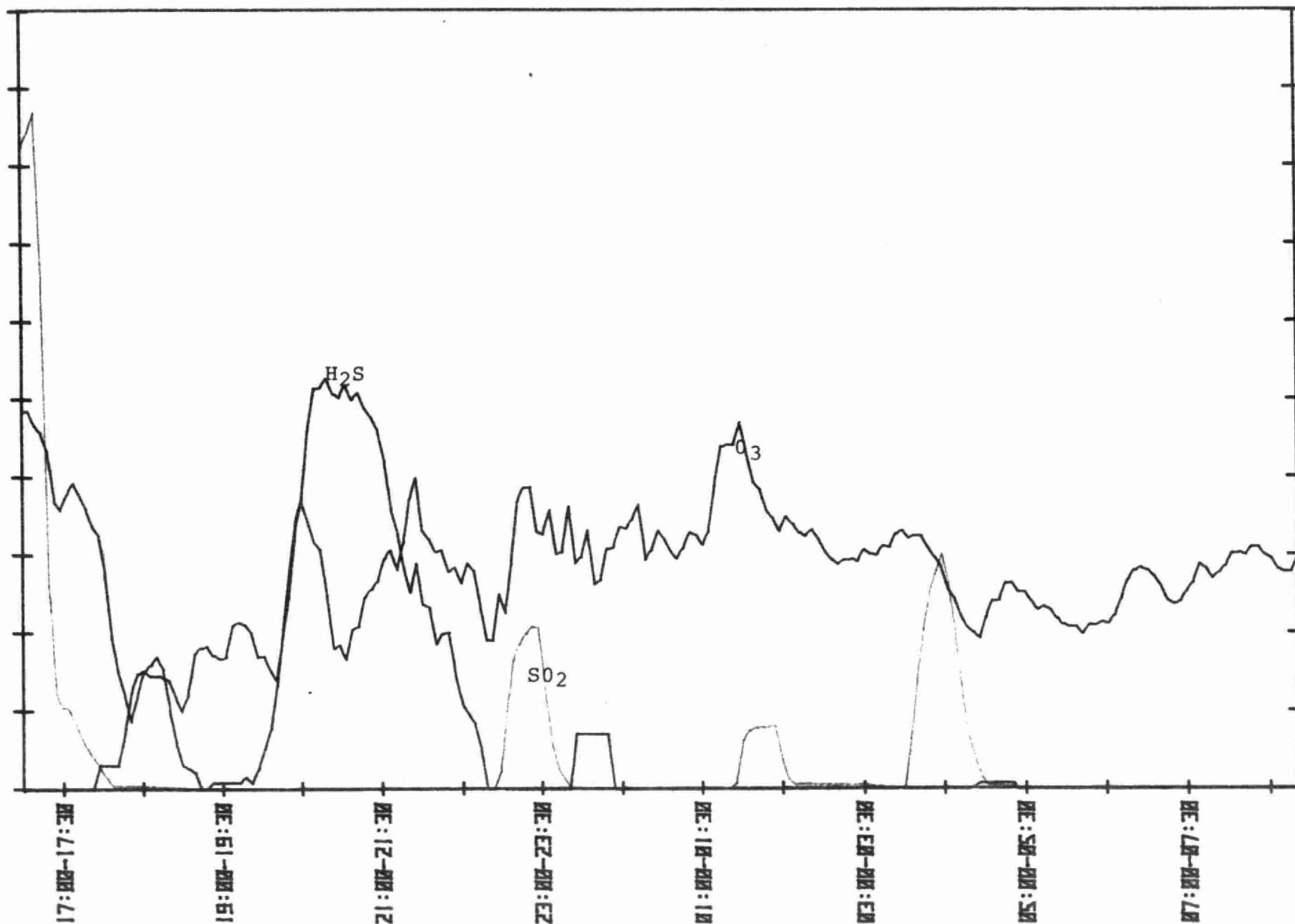
.0

.0

H2S

SO2

CO



STANDARD

Gas	Concentration (PPM)	Unit
H2S	0.02	PPM
SO2	0.30	PPM
CO	0.10	PPM

TIME

MAP #4

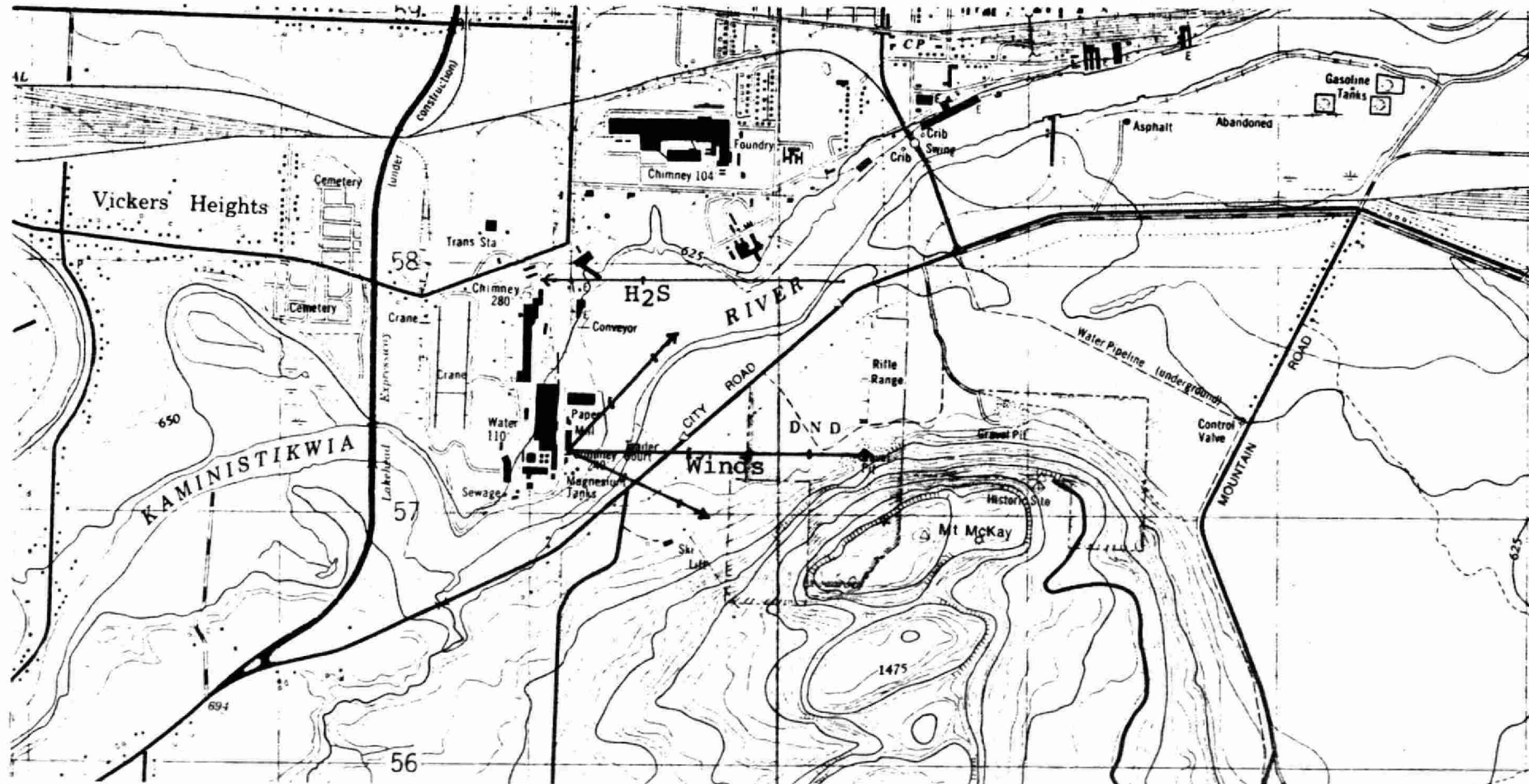
THUNDER BAY 11 #2

18:13 OCT 21 1977
 LENGTH= 2 HRS
 DELAY= 0 MIN
 LOC: HWY #61B/(33025-53578), 1.2KM, 45 DEG/SOURCE

SCAN= 60 SEC AVE= 30 MIN
 MINIMUM MEAN= 5.00000E-03 PPM
 WIND RANGE= 0 / 5 KM/HR

ARITHMETIC MEAN: H2S
 1 DIV= 0.01 PPM

PREVAILING WINDS; BLOWING TOWARDS:
 1 DIV= 10 %



THUNDER BAY 11 #37

SCAN= 50 SEC AVE= 30 MIN
MINIMUM MEAN= 5.00000E-03 PPM
WIND RANGE= 0 / 20 KM/HR
(33050-53583), 1.7KM, 53 DEG/SOURCE

1 DIV = 0.01 PPM

PREVAILING WINDS; BLOWING TOWARDS:
1 DIV= 10 %

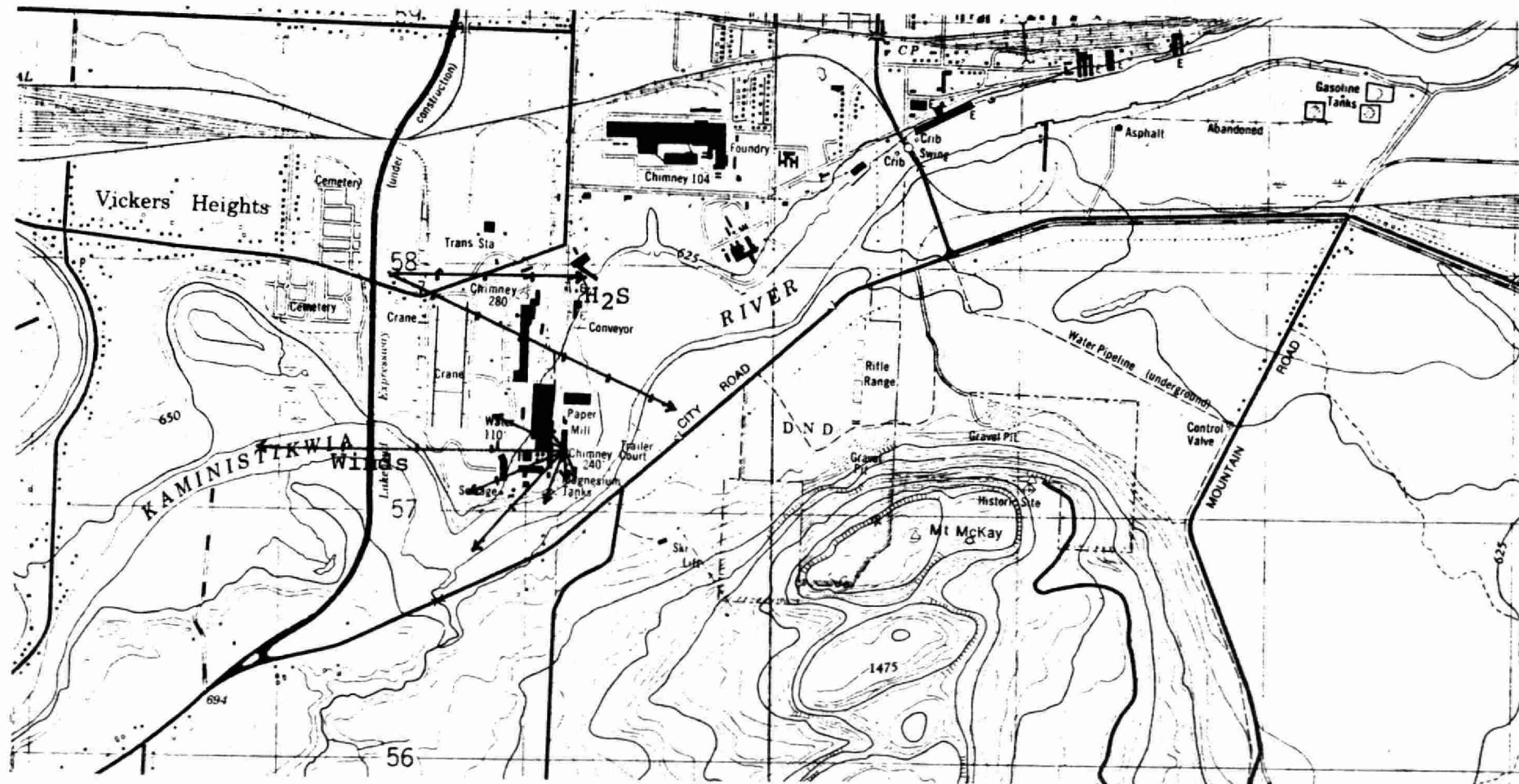


MAP #6

THUNDER BAY 11 #46

18:04 NOV 6 1977
LENGTH= 14.8 HRS
DELAY= 0 MIN
LOC: BROADWAY ST. & HWY #61; (32835-53580), 1KM, 315 DEG/SOURCE
SCAN= 120 SEC AVE= 30 MIN
MINIMUM MEAN= 1.00000E-03 PPM
WIND RANGE= 0 / 15 KM/HR

ARITHMETIC MEAN: H2S
1 DIV= 1.00000E-03 PPM
PREVAILING WINDS; BLOWING TOWARDS:
1 DIV= 10 %



MAP #7

THUNDER BAY II #6

16:41 OCT 21 1977

LENGTH= 2.8 HRS

DELAY= 0 MIN

LOC: MT. MCKAY SKI AREA; (32950-53570); 0.7KM, 135 DEG/SOURCE

SCAN= 30 SEC AVE= 30 MIN

MINIMUM MEAN= 1.0000E-03 PPM

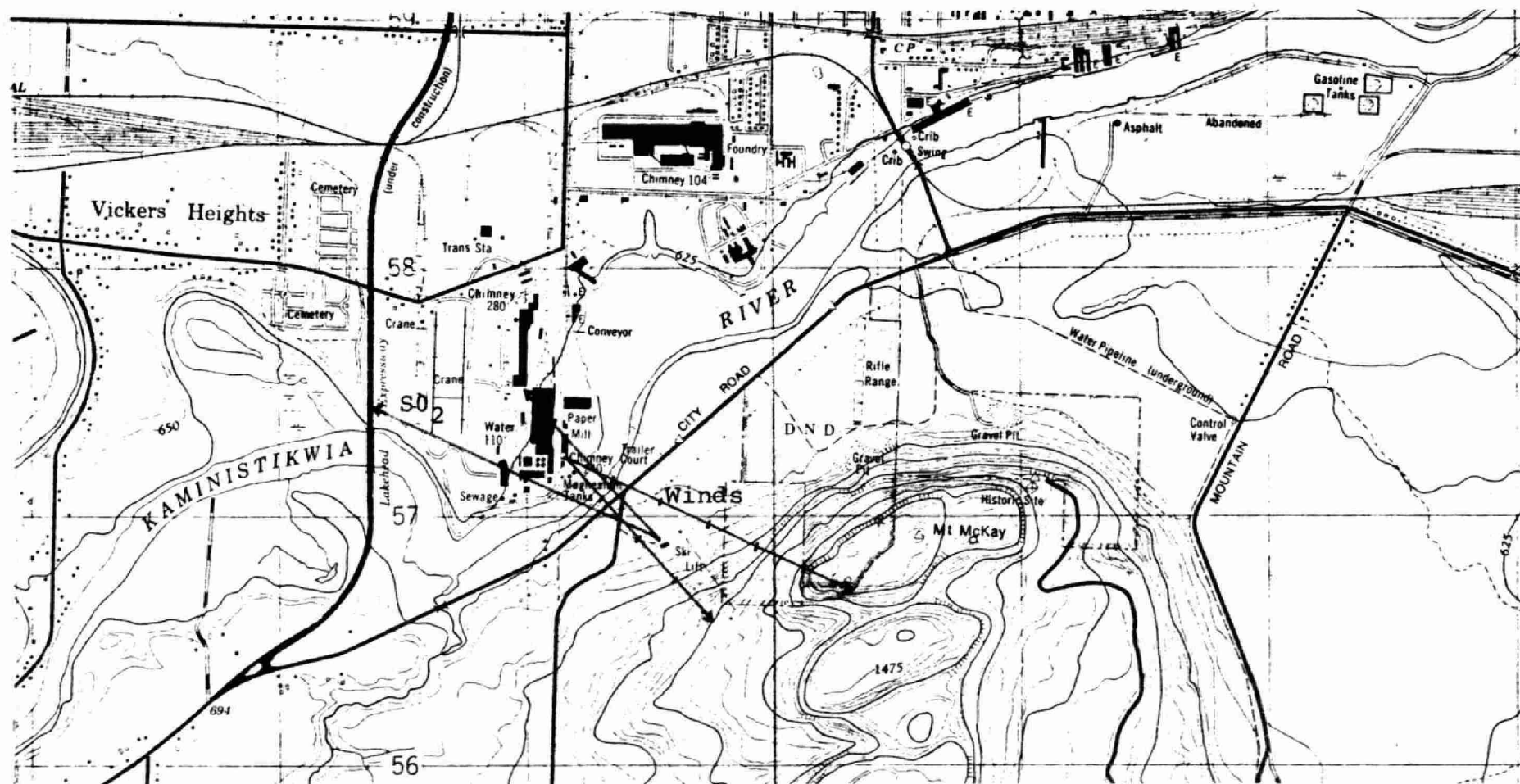
WIND RANGE= 0 / 15 KM/HR

ARITHMETIC MEAN: 502

1 DIV= 0.01 PPM

PREVAILING WINDS; BLOWING TOWARDS:

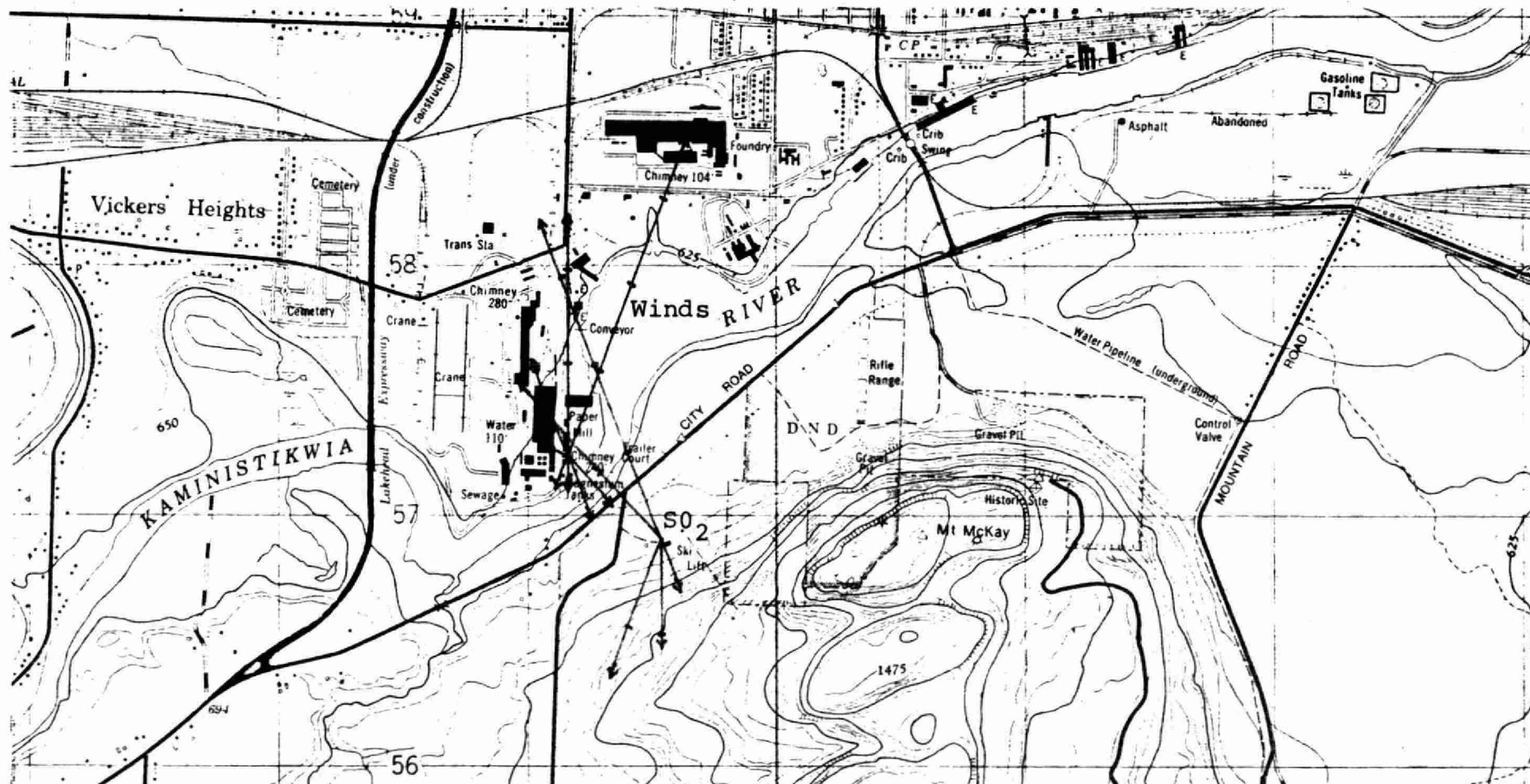
1 DIV= 10 %



THUNDER BAY 11 #7

SCAN= 60 SEC AVE= 30 MIN
MINIMUM MEAN= 5.00000E-03 FPM
WIND RANGE= 0 , 10 KM/HR
0-53570), 0.7KM, 135 DEG/SOURCE

ARITHMETIC MEAN: 502
1 DIV = 0.01 PPM
PREVAILING WINDS; BLOWING TOWARDS:
1 DIV = 10 %

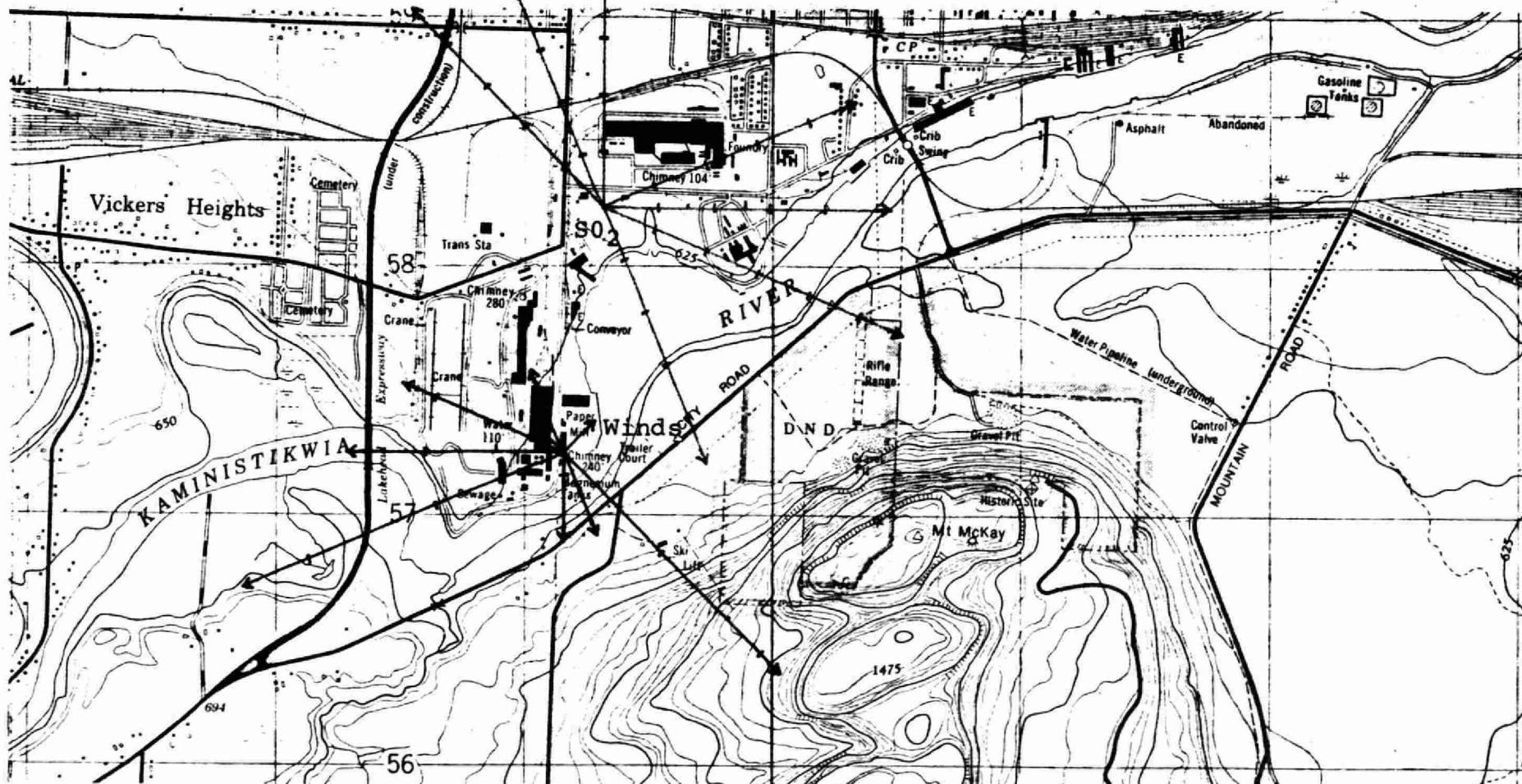


MAP #9

THUNDER BAY II #17

16:18 OCT 24 1977
 LENGTH= 16.2 HRS
 DELAY= 0 MIN
 LOC: CAN CAR LTD PROPERTY; (32945-53583), 1KM, 20 DEG/SOURCE
 SCAN= 60 SEC AVE= 30 MIN
 MINIMUM MEAN= 4.00000E-03 PPM
 WIND RANGE= 0 / 15 KM/HR

ARITHMETIC MEAN: 502
 1 DIV= 1.00000E-03 PPM
 PREVAILING WINDS; BLOWING TOWARDS:
 1 DIV= 10 %



MAP #10

THUNDER BAY 11 #18

11:18 OCT 25 1977

LENGTH= 4.5 HRS

DELAY= 0 MIN

LOC: CAN CAR LTD PROPERTY; (32945-53583), 1KM, 20 DEG/SOURCE

SCAN= 60 SEC AVE= 30 MIN

MINIMUM MEAN= 5.80000E-03 PPM

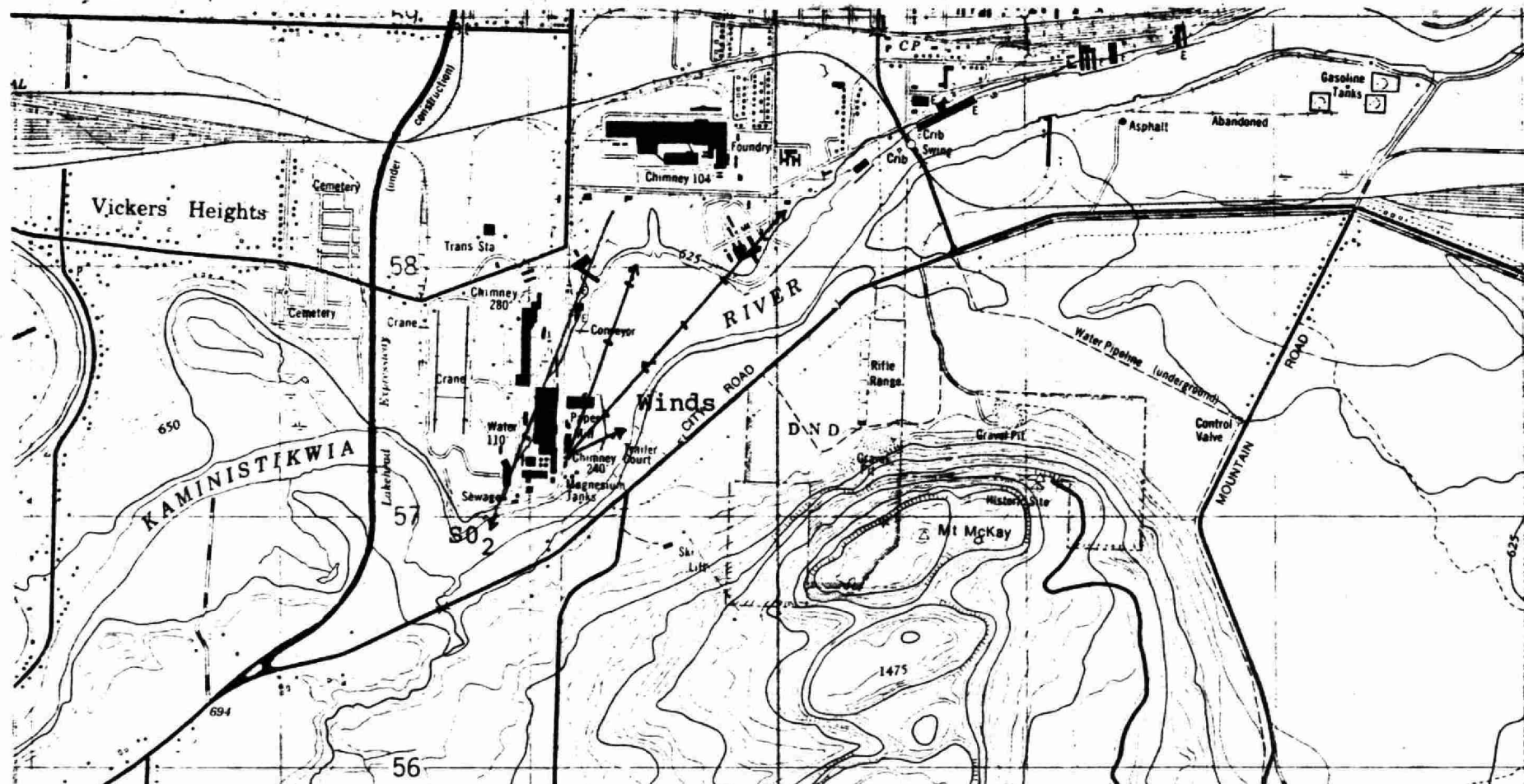
WIND RANGE= 5 , 30 KM/HR

ARITHMETIC MEAN: 502

1 DIV= 0.01 PPM

PREVAILING WINDS; BLOWING TOWARDS:

1 DIV= 10 %



MAP #11

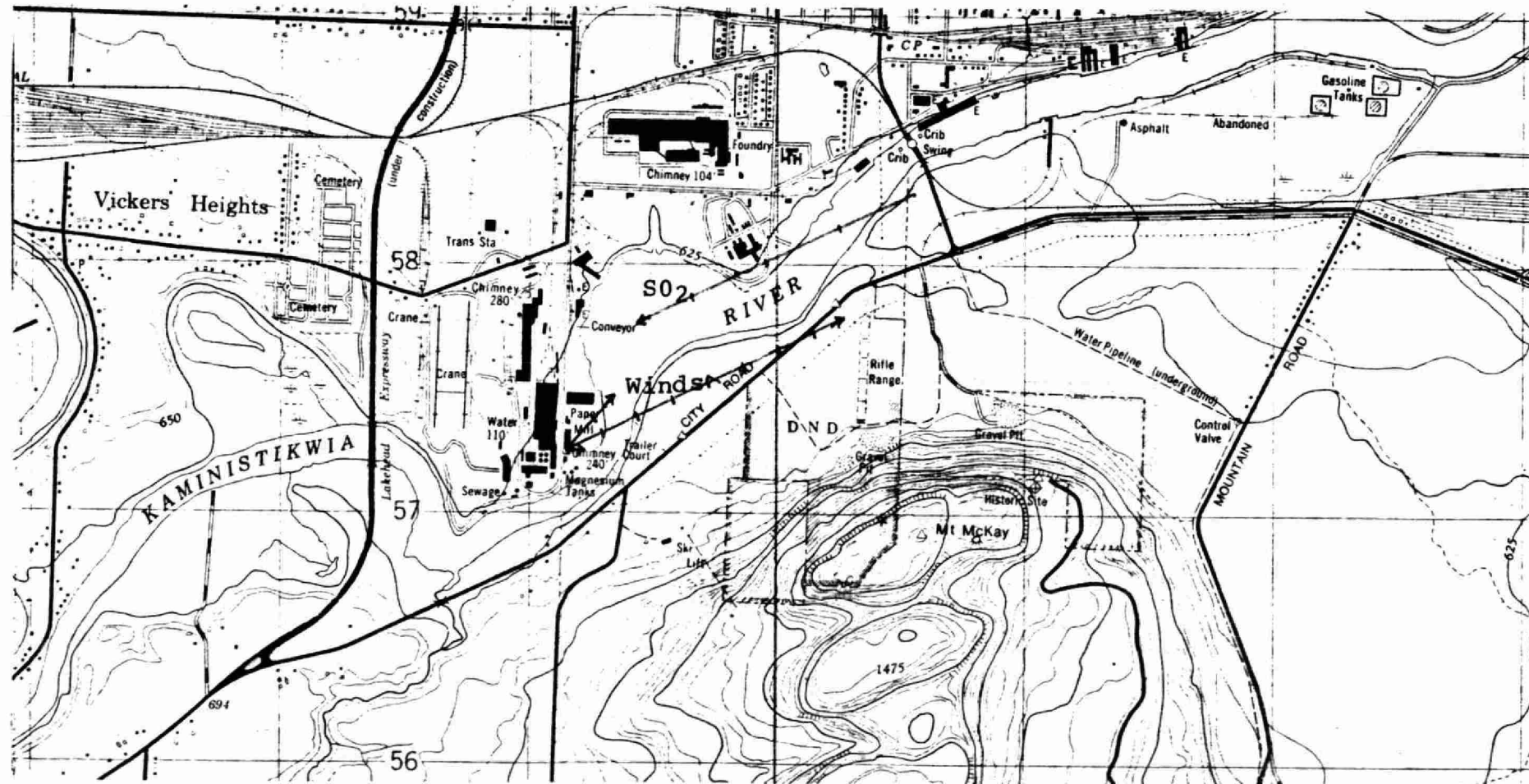
THUNDER BAY 11 #19

16:19 OCT 25 1977
LENGTH= 11.6 HRS
DELAY= 0 MIN
LOC: C.N.R.A. RECREATION RINK; (33055-53584); 1.7KM/ 50 DEG/SOURCE

SCAN= 90 SEC AVE= 30 MIN
MINIMUM MEAN= 5.00000E-03 PPM
WIND RANGE= 0 , 25 KM/HR

ARITHMETIC MEAN: 502
1 DIV= 0.01 PPM

PREVAILING WINDS; BLOWING TOWARDS:
1 DIV= 10 X



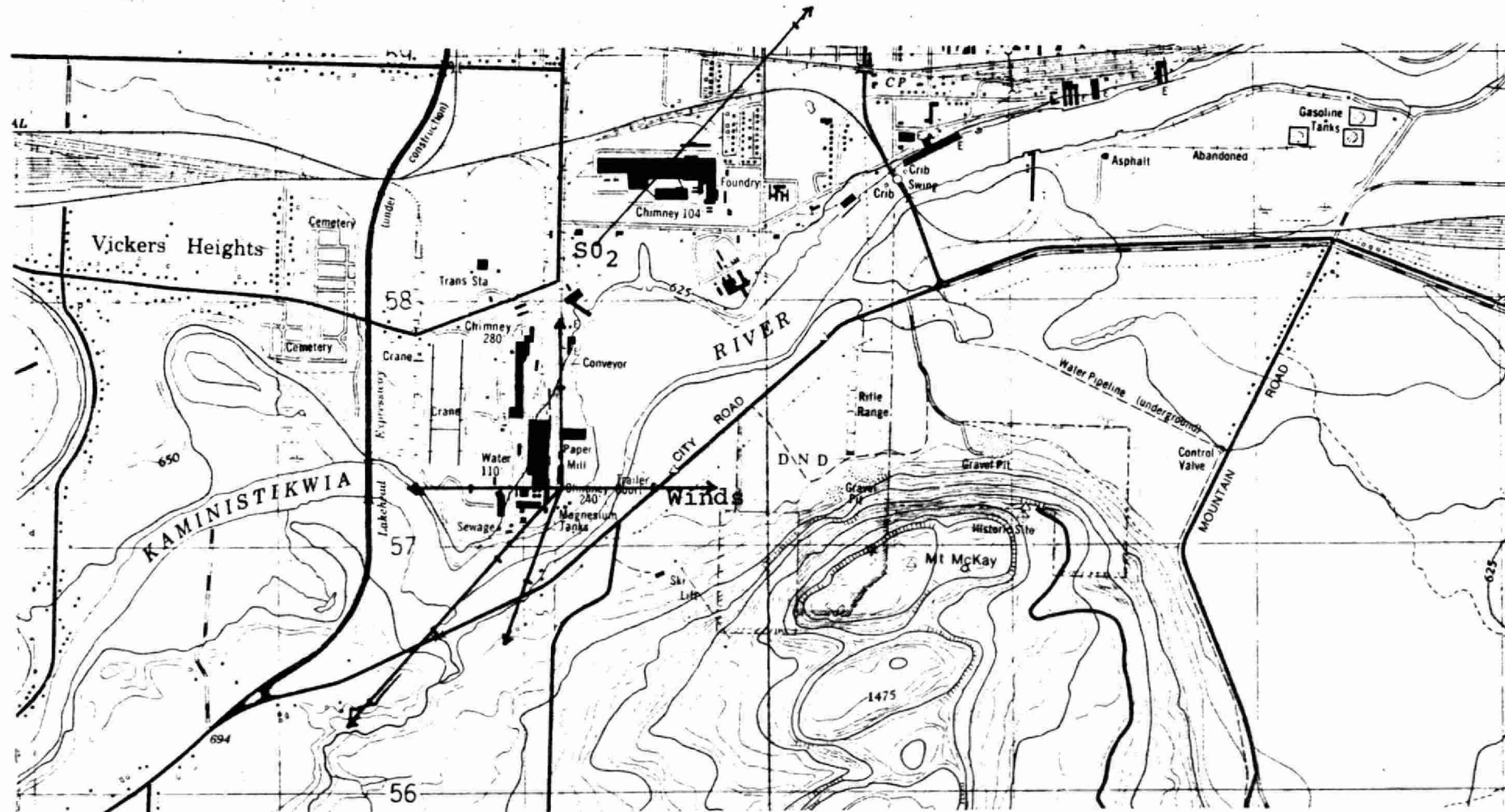
MAP #12 THUNDER BAY II #31

09:54 NOV 2 1977
LENGTH= 3.4 HRS
DELAY= 0 MIN
LOC: CAN CAR LTD LOT: (32945-53583), 0.85KM, 15 DEG/SOURCE

SCAN= 60 SEC AVE= 30 MIN
MINIMUM MEAN= 1.00000E-03 PPM
WIND RANGE= 0 / 10 KM/HR

ARITHMETIC MEAN: 502
1 DIV= 0.01 PPM

PREVAILING WINDS; BLOWING TOWARDS:
1 DIV= 10 %



MAP #13

THUNDER BAY II #37

1919 NOV 3 1977

LENGTH= 13.7 HRS

DELAY= 0 MIN

LOC: C.N.R.A. RECREATION RINK (33080-53503), 1.7KM, 55 DEG/SOURCE

SCAN= 60 SEC AVE= 30 MIN

MINIMUM MEAN= 5.00000E-03 PPM

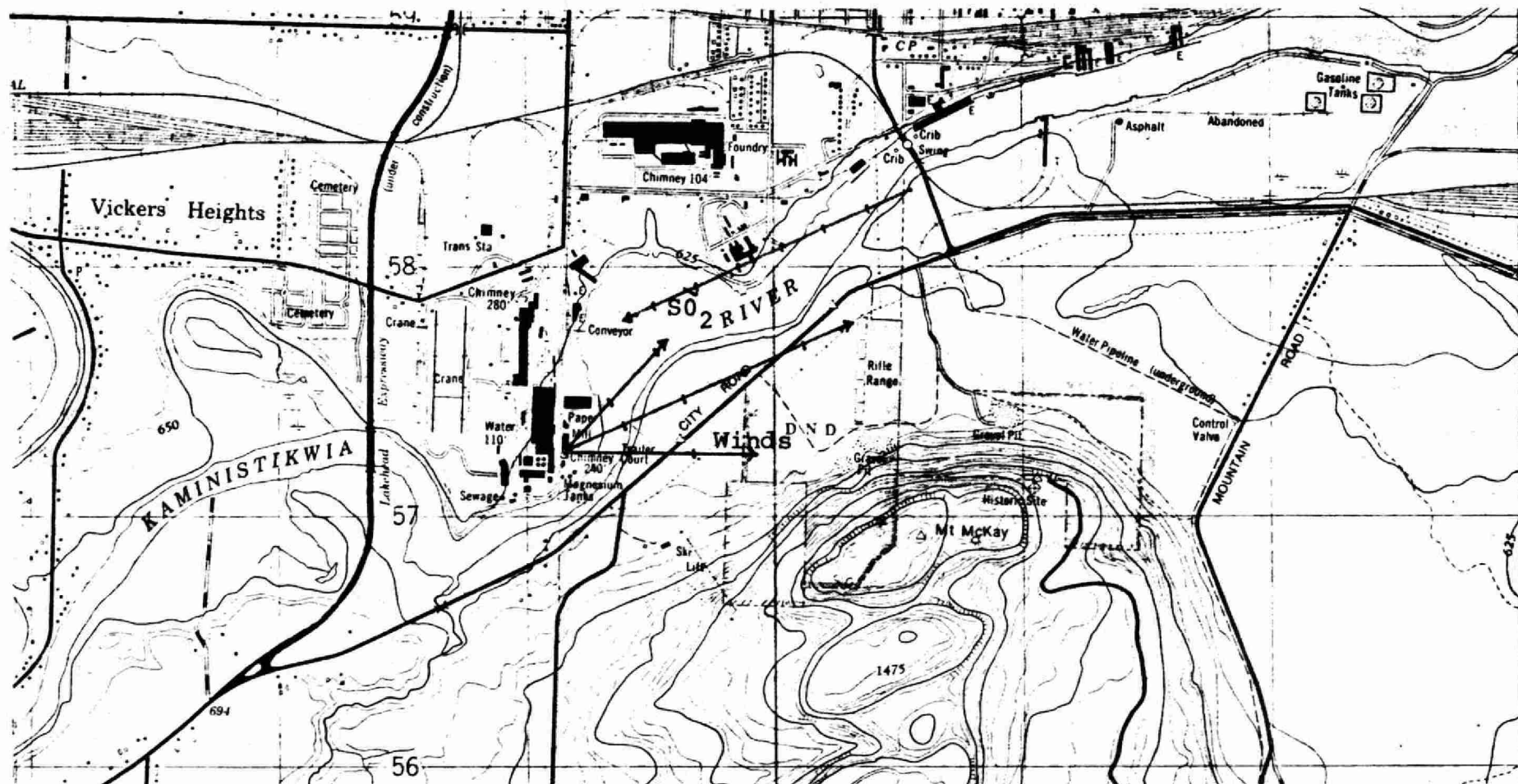
WIND RANGE= 0 / 20 KM/HR

ARITHMETIC MEAN: 502

1 DIV= 1.00000E-03 PPM

PREVAILING WINDS; BLOWING TOWARDS:

1 DIV= 10 %



MAP #14

THUNDER BAY 11 #38

09:17 NOV 4 1977

LENGTH= 3.9 HRS

DELAY= 0 MIN

LOC: INDIAN RESERVE LOOKOUT RD.; (33178-53571); 2.6KM, 118 DEG/SOURCE

SCAN= 60 SEC AVE= 30 MIN

MINIMUM MEAN= 0.02 PPM

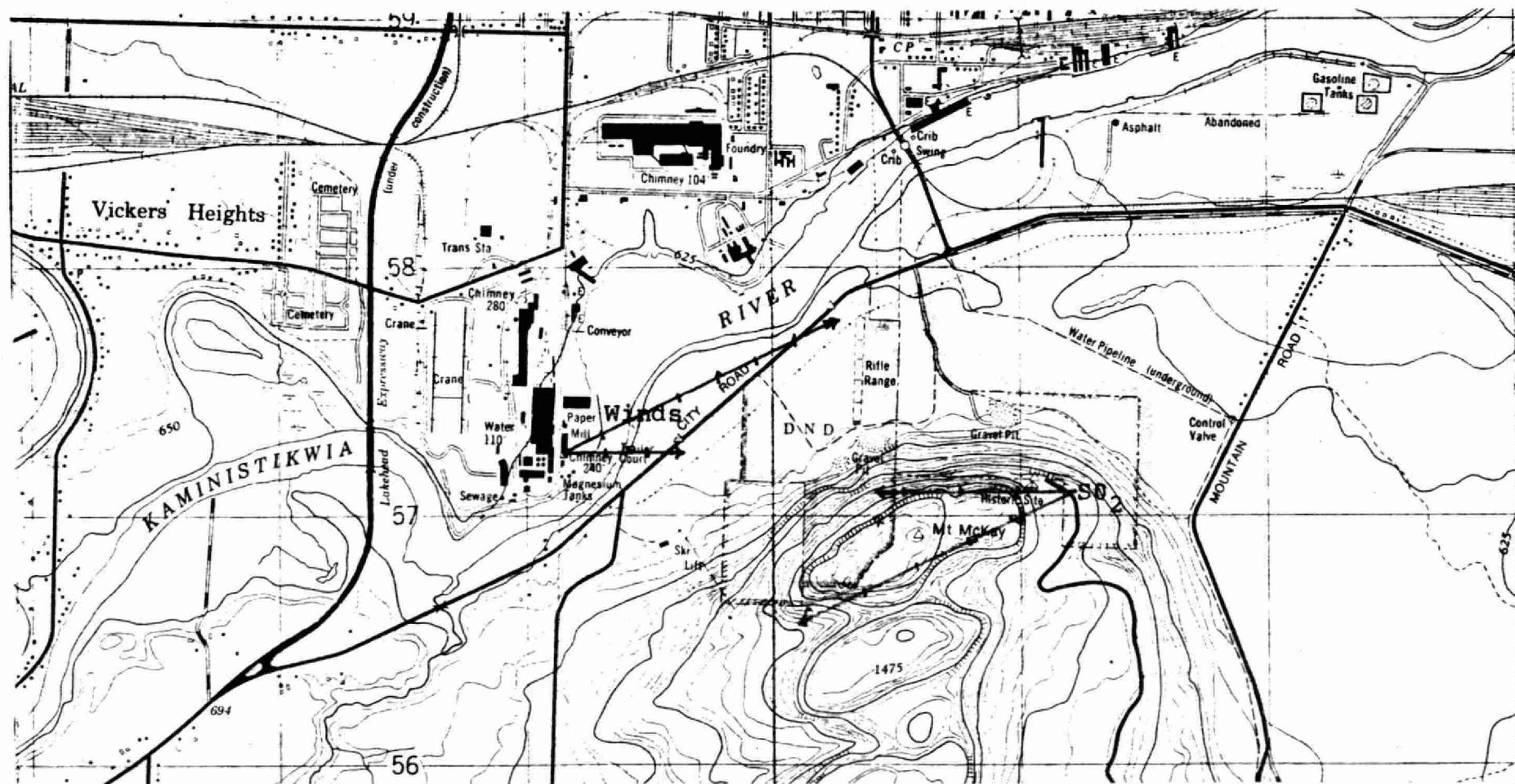
WIND RANGE= 0 / 10 KM/HR

ARITHMETIC MEAN: 502

1 DIV= 0.01 PPM

PREVAILING WINDS; BLOWING TOWARDS:

1 DN= 10 %

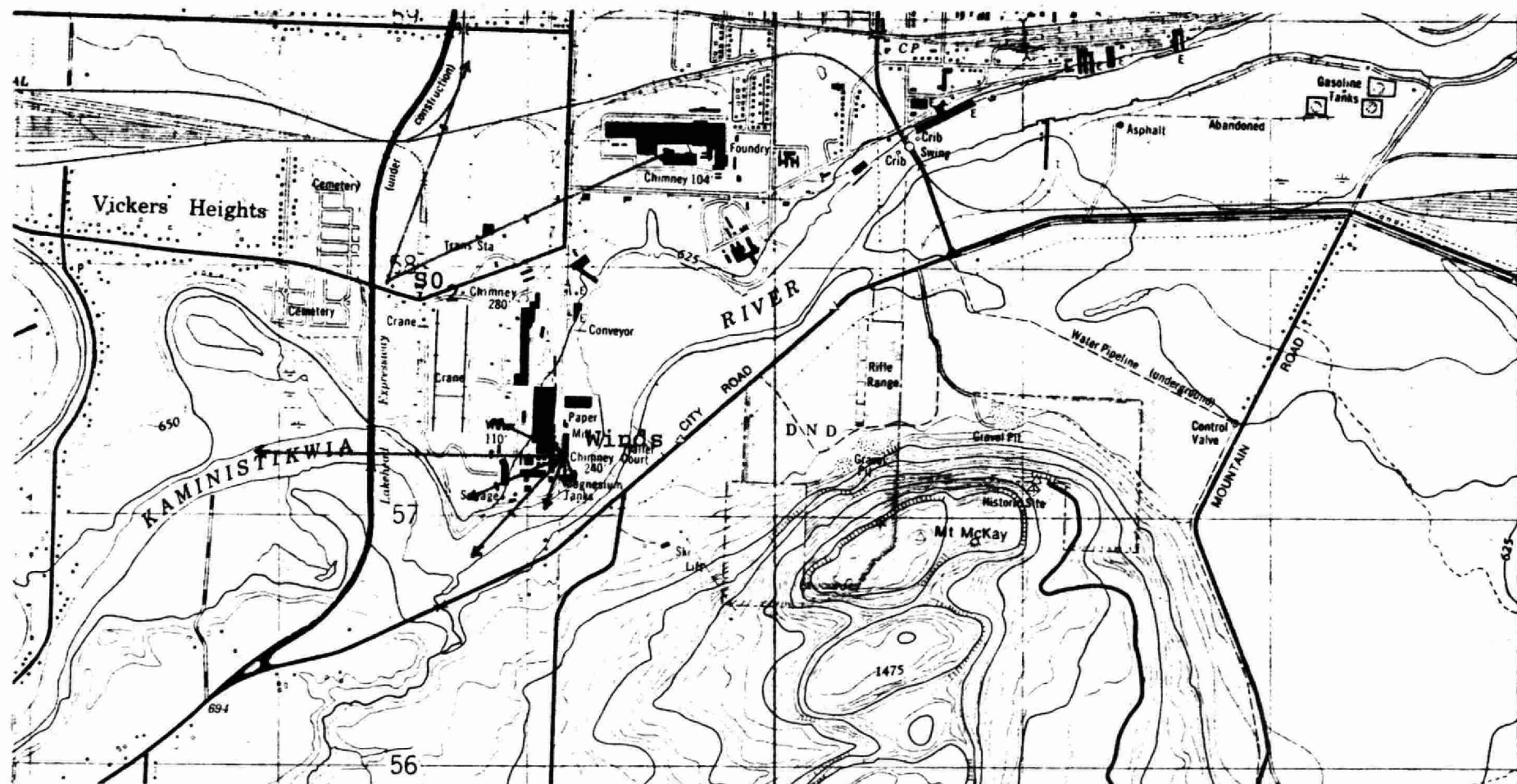


MAP #15

THUNDER BAY 11 #46

18:04 NOV 6 1977
 LENGTH= 14.6 HRS
 DELAY= 0 MIN
 LOC: BROADWAY ST. & HWY #61; (32835-53588), 1KM, 315 DEG/SOURCE
 SCAN= 120 SEC AVE= 30 MIN
 MINIMUM MEAN= 1.00000E-04 PPM
 WIND RANGE= 0 / 15 KM/HR

ARITHMETIC MEAN: 502
 1 DIV= 1.00000E-04 PPM
 PREVAILING WINDS; BLOWING TOWARDS:
 1 DIV= 10 %

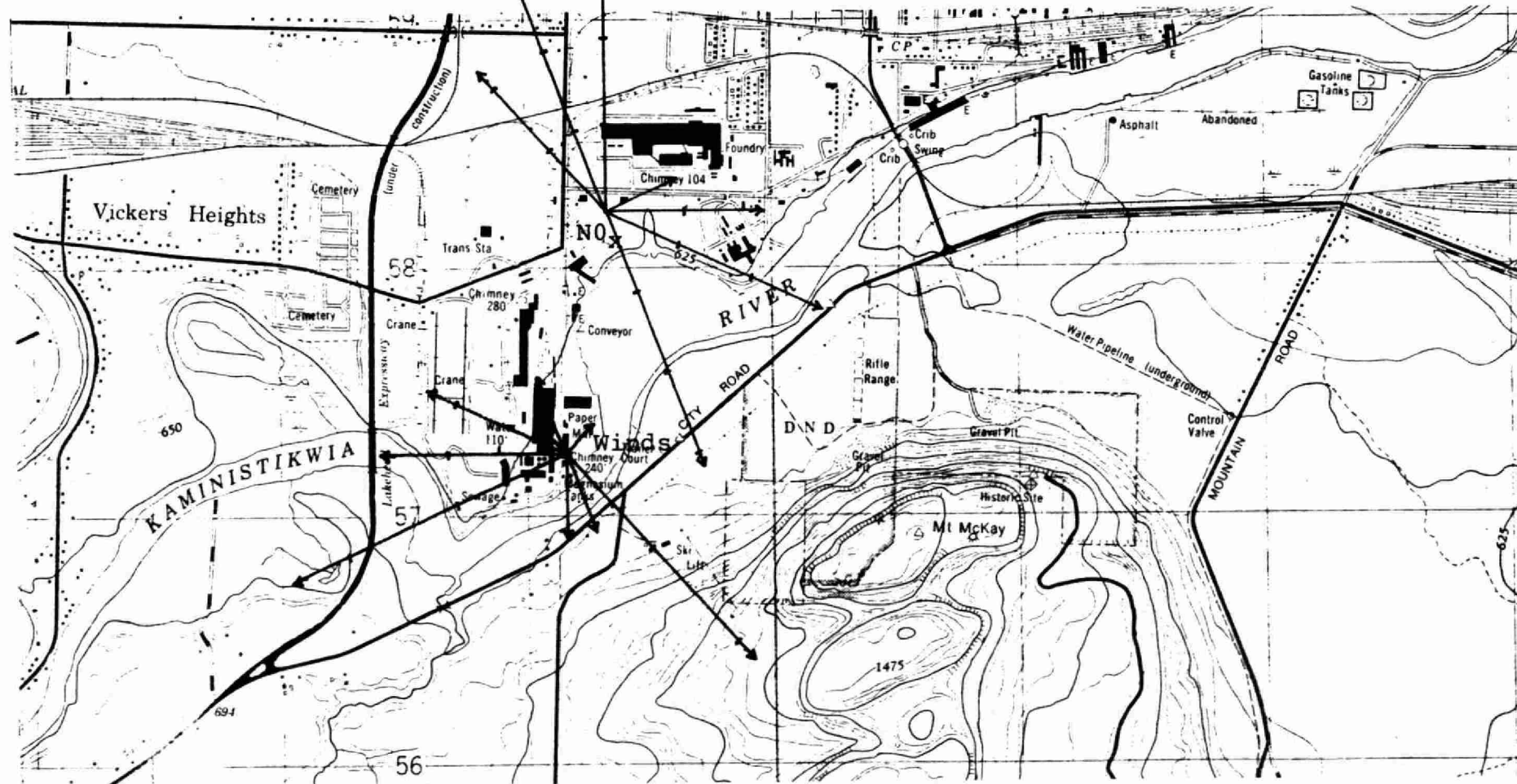


MAP #16

THUNDER BAY II #17

16:18 OCT 24 1977 SCAN= 60 SEC AVE= 30 MIN
LENGTH= 16.2 HRS MINIMUM MEAN= 5.00000E-03 PPM
DELAY= 0 MIN WIND RANGE= 0 , 10 KM/HR
LOC: CAN CAR LTD PROPERTY; (32545-53583), 1KM, 20 DEG/SOURCE

ARITHMETIC MEAN: NOX
1 DIV= 0.1 PPM
PREVAILING WINDS; BLOWING TOWARDS:
1 DIV= 10 %





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MOE/THU/REP/AMWC

DATE DUE			

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Ontario Ministry of the En
Report on ambient
air quality survey amwc
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